TN
939
S33
v. 19
c. 1
ENGS

Subsal E

MEMOIRS OF THE GEOLOGICAL SURVEY

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

NGI STORAGE

VOL. XIX.—LEAD AND ZINC ORES IN THE CARBONIFEROUS ROCKS OF NORTH WALES.

BY BERNARD SMITH, M.A.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

GEOLOGICAL SURVEY OFFICE WHITEHAVEN

LONDON:
PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S STATIONERY OFFICE.

And to be purchased from
E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C. 2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & Co., LTD., 20, NASSAU STREET, and 17 & 18, FREDERICK STREET, DUBLIN;
or from any Agent for the sale of Ordnance Survey Maps; or through any Bookseller from the DIRECTOR-GENERAL, ORDNANCE SURVEY OFFICE, SOUTHAMPTON.

1921.

Price 5s. 6d. Net.

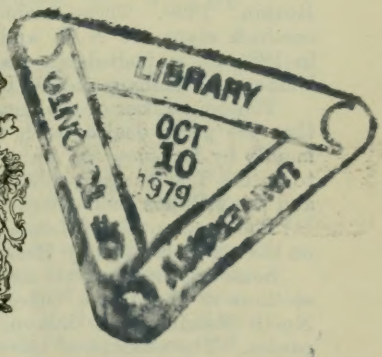
MEMOIRS OF THE GEOLOGICAL SURVEY.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

VOL. XIX.—LEAD AND ZINC ORES IN THE CARBONIFEROUS ROCKS OF NORTH WALES.

BY BERNARD SMITH, M.A.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.



LONDON:
PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S STATIONERY OFFICE.

And to be purchased from
E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C. 2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & Co., LTD., 20, NASSAU STREET, and 17 & 18, FREDERICK STREET, DUBLIN;
or from any Agent for the sale of Ordnance Survey Maps; or through any Bookseller from the DIRECTOR-GENERAL, ORDNANCE SURVEY OFFICE, SOUTHAMPTON.

1921.

Price 5s. 6d. Net.

PREFACE.

In North and Central Wales lead and zinc mining has been most successfully prosecuted, and the importance of the mines, together with the varieties of the geological conditions presented by the lodes and the surrounding strata, has made it desirable to enter into considerable detail in the description of the mineral resources of that district. Accordingly the subject has been divided into three parts of which this memoir on the ores in the Carboniferous rocks is the first to appear. A second volume will deal with the ores of the Silurian rocks of Central Wales, while a third will be devoted to the consideration of the ores in the pre-Carboniferous rocks of North Wales; these are now in the press and will shortly be published.

The group of mines described in this memoir includes some of the largest lead and zinc producers in Britain, such as the celebrated Minera Mine. Some of the veins have yielded over a million pounds worth of ore, and it seems probable that the district is by no means exhausted, but that, if trade conditions permit, mining may be successfully carried on again on a large scale.

The author in preparing the memoir has consulted all the available authorities, and has by the kindness of those in charge of the mines had facilities afforded him for examining the mine plans, records, and the actual workings, so far as was desirable, for the preparation of an account which, while comprehensive, was necessarily brief, owing to the exigencies of space. The plans of abandoned mines deposited in the Home Office have also been consulted, and every effort made to ensure that this memoir would contain an accurate and reasonably complete account of the geology of the mines and lodes.

An account of the majority of the lodes traversing the northern parts of the district was included in two of the Geological Survey memoirs, viz. 'The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn,' 1885, and 'The Geology of the Neighbourhoods of Flint, Mold, and Ruthin,' 1890. These memoirs, together with the relative Old Series one-inch maps (79 N.W. and 79 S.E., of which new editions were issued in 1885-6), embodied the results of a six-inch survey by Messrs. Aveline, Tiddeman, Strahan, and De Rance.

Though neither of the memoirs is out of print, it has been felt desirable that the parts dealing with the lead and zinc mining, which were written mainly by Mr. (now Sir Aubrey) Strahan, should be revised and brought up to date. The necessary field-work was carried out in 1919 by Mr. Smith, and the MS. has been edited by Mr Cantrill.

The area south of Llanarmon falls within the district recently revised on the six-inch maps by Messrs. C. B. Wedd, H. H. Thomas, and B. Smith.

Some of the illustrations in the present volume are based on plans and sections at the Home Office, and on those in possession of the Halkyn, North Hendre, East Halkyn, Holywell-Halkyn, and Minera Mining Companies. The sections of the mines are intended to show general characters or features of special geological interest, not necessarily to exhibit the richest parts of the lodes.

The author desires to acknowledge his indebtedness to the numerous Mining Engineers, Directors, and Managers of the mines, more especially to Captains M. and J. Francis of the Halkyn Mines, Mr. J. Philip Jones of the Holywell-Halkyn Mining and Tunnel Company, Mr. Taylor of the Hendre Mines, Mr. Edward Powell of the Rhosesmor Mines, Captain Robert J. Roberts of the Pant-y-buarth Mine, and Mr. G. F. Wynne of the Minera Mines.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street, London, S.W.1,
16th March, 1921.

CONTENTS.

PAGE

PREFACE BY THE DIRECTOR ii

CHAPTER I.—INTRODUCTION 1
Historical Data, 1. Outline of Geology, 3. The Ores: character, distribution, and origin, 7. Output, 14. Analyses and Assays, 18. Mining and Drainage, 21.

CHAPTER II.—OLD MINES AND MINES RECENTLY ABANDONED 30
Area 1.—*Vale of Clwyd.* Geology, 30. Mines and Lodes, 31.

CHAPTER III.—OLD MINES AND MINES RECENTLY ABANDONED 36
Area 2.—*Prestatyn to the Bala Fault* (Llandegla and Hope Mountain). Geology, 36. Mines and Lodes. 1.—Dyserth to Whitford, 38. 2.—Whitford to Holywell and Halkyn, 49. 3.—Halkyn Mountain, 61. 4.—Bryn-gwiog to Rhydymwyn, 73. 5.—Rhydymwyn to Gwern-y-mynydd, 80. 6. — Gwern-y-mynydd to Maes-y-safn, 92. 7.—Maes-y-safn to Llandegla, 97. 8.—Llandegla to Minera, 102.

CHAPTER IV.—OLD MINES AND MINES RECENTLY ABANDONED 103
Area 3.—*The Bala Fault* (Bwlch-gwyn and Minera) *to Llanymynech.* Geology. Mines and Lodes, 103.

CHAPTER V.—MINES RECENTLY SUSPENDED, AND WORKING MINES (in Geographical order from North to South) 117
Waen and Merllyn Mine, 117. The Milwr Tunnel and the Lodes cut, 118. Milwr Mine, 124. New Caeau Mine, 126. Plâs-Winter Mine, 127. The Halkyn Mines, 128. East Halkyn Mine, 134. North Hendre Mine, 138. Garreg-boeth Lode (East), 143.

APPENDIX.—Plans of Abandoned Mines 146

INDEX 148

(78)13482 Wt 31173—S 1/663 750 8/21 E & S A 2

ILLUSTRATIONS.

Text-Figures.

		PAGE
Fig.	1.—General Map, Abergele to Llangollen	6
„	2.—Map of Drainage-Areas, Milwr and Halkyn	24
„	3.—Sections of Talargoch Vein: 1, along the vein; 2, across the vein	39
„	4.—Section of Waen or Merllyn Mine, Holywell	56
„	5.—Section of Deep Level Mine, Halkyn	69
„	6.—Map of Drainage-Area and Lodes, Halkyn	71
„	7.—Section across Nant-figillt and Southern end of Halkyn Mountain	74
„	8.—Plan of workings in the North Hendre Flat, 1879	75
„	9.—Section (diagrammatic) showing Flats in North Hendre Mine	76
„	10.—Section of Bryn-celyn Lode, Rhydymwyn	80
„	11.—Section of Llyn-y-pandy Mine, Rhydymwyn	83
„	12.—Section of Pant-y-mwyn Mine (East End)	85
„	13.—Section of Maes-y-safn Lode	95
„	14.—Map of the Minera Mining District	104
„	15.—Sections of Taylor's, Roy's, and the Meadow Shafts, Minera Mines	106
„	16.—Graph showing Output and Value of Lead and Zinc Ores, Minera Mines	111
„	17.—Sections of Herward and Milwr Shafts	120
„	18.—Loch or Vugh on the Pant Lode, intersected by the Milwr Tunnel	122
„	19.—Section of Beili-gwyn or No. 2 Lode, Milwr Mine ...	125
„	20.—Section of New Pant-y-gôf Lode, Halkyn Mines	129
„	21.—Section of Great Halkyn or 'Bryn-gwiog' Vein, Halkyn Mines	131
„	22.—Section of Powell's Lode, East Halkyn (Rhosesmor) Mines	135
„	23.—Plan (diagrammatic) showing flats on north side of Powell's Lode	136
„	24.—Section of the Hendre or Coed-Hendre Lode, Hendre Mine	140
„	25.—Section of Garreg-boeth Lode, South Halkyn Mine ...	143

Plates.

Plate	I.—Graph showing Outputs of Lead, Silver, and Zinc in Flintshire ... ... *facing*	14
„	II.—Graph showing Outputs of Lead, Silver, and Zinc in Denbighshire ... ... *facing*	14
„	III.—Longitudinal Sections of the Cat Hole, Gwern-y-mynydd, Westminster, Bog, and Belgrave Mines *facing*	98

LEAD AND ZINC ORES
IN THE
CARBONIFEROUS ROCKS
OF
NORTH WALES.

CHAPTER I.

INTRODUCTION.

Historical Data.

It is generally believed that the ores of lead and zinc in North Wales have been worked more or less continuously from Roman times or earlier, though many of the mines have been abandoned and reopened from time to time.

Although amongst the multitudes of shallow shafts and open trenches along the veins it is generally difficult to distinguish any as being certainly of Roman origin, yet many of the mines are traditionally attributed to this date, such as the Ffôs-y-bleiddiaid Mine near Abergele, the Talargoch Mine, the Minera Mine, and also the old mine on Llanymynech Hill, where Roman coins have been found in the old workings. At Ffôs-y-bleiddiaid (p. 32) some curious hammers and other tools were found, together with the golden hilt of a Roman sword. Pennant[1] describes the discovery of an ancient iron wedge coated with a deposit of lead, found in working the deep fissures at Talargoch in the parish of Dyserth. The same writer, giving reasons for supposing that the lead-ore was smelted at a place called Croes-ati near Flint, says: "There is a tradition that "in very old times stood a large town at this place; and it is "said that the foundations of buildings have been frequently "turned up by the plough. But more remarkable are the great "quantities of scoria of lead, bits of lead ore, and fragments of "melted lead, which have been discovered in several spots "here, and along the country, just above the shore, in the "adjoining parish of *Northop*. These have of late been found "to contain such quantities of lead as to encourage the washers "of ore to farm the spots. In this tract, numbers of tons have "been gotten within a small time, especially at Pentre Ffwrndan, "or the *place of the fiery furnace*; a name it was always known

[1] 'The History of the Parishes of Whiteford and Holywell,' 4to., *Lond.*, 1796, p. 122.

" by, and which evinces the antiquity of smelting in these " parts."[1] He adds that the multitudes of Roman coins, fibulæ, and a variety of antique instruments, lately discovered by the workmen in the old washes of this and the next parish, prove that the Romans made Flint their port for exporting the metal. Clumsy pick-axes, of uncommon size, have been discovered in the bottoms of some of the mineral trenches. Buckets of singular construction, and other tools also have been found among the ancient mines.[2] When the ore was got it was cleaned in a rude way, smelted, and cast into rough pigs. The discovery of several such pigs of lead, bearing the stamps of Roman Emperors, near the borders of North Wales, indicates that ore was both raised and smelted in the neighbourhood.

The uses of calamine also were known to the Romans in the making of brass, but all local knowledge of it was afterwards lost, until about 60 years before Pennant recorded that the mineral had been used for mending the local roads.[3]

Since those days the working of the ores has continued at intervals up to the present time. That the Saxons as well as the Romans worked the British mines appears from the frequent employment of lead in their ecclesiastical buildings. The Crown for many centuries after the Norman Conquest assumed the entire claim to all mines and minerals. In 1283 the burgesses of Flint received from Edward I a grant of timber out of the woods of Northop, Ledebroke the greater and lesser, Keldreston, Wolfynton, Weper and Sutton, in order to smelt their lead-ore. Edward I directed tithes of ore out of the neighbouring mines to be paid to the parochial churches in Wales. The Abbey of Basingwerk also had a revenue arising from the same source. Edward also continued the mineral grants to several important personages. Sir John Petters preserved a series of grants, from the reign of Edward I to that of Henry VII, empowering different persons to search for ore in particular counties or in the Kingdom in general.

Queen Elizabeth, in order to revive the metal industries of this country, which had fallen into the hands of foreigners, formed a corporation, 'The Society of Mines Royal,' and in 1563 granted the mines and minerals of Wales and several English counties to various people to work.

Charles I made a grant of all the mines of lead or rakes of lead within the hundreds of Coleshill and Rhuddlan to Sir Richard Grosvenor, Knight. These tracts were, at an earlier date, set on leases for a certain term of years. Thus James I granted a lease to Richard Gwynne on payment of the annual acknowledgment of sixty-six shillings and eight-pence, and a new one was granted to others in 1629.

---

[1] 'A Tour in Wales in 1773,' 8vo., *Lond.*, vol. i, pp. 71, 72.

[2] *Op. cit.*, vol. i, p. 75. *See also* 'British Mining,' by R. Hunt, 8vo., *Lond.*, 1884, pp. 29, 30.

[3] 'Tours in Wales,' vol. i, p. 88.

A rich discovery of ore was made near the Pant Lode near Halkyn in 1728. In 1771 there were exported from Chester to foreign parts 1,000 tons of lead and 300 tons of lead-ore; and 3,470 tons of lead and 431 of ore were sent coastways to London and Liverpool for re-exportation.

About 1770 a rich vein was discovered at Rowley's Rake or Pant-y-pwll-dwr on Halkyn Mountain. In less than 30 years it yielded above a million of money. Pennant gives a description of the Holywell Level (p. 49) as it was in 1795. The village of Pentre-Halkyn took its rise between 1800 and 1810, on the discovery of a rich vein of lead in the adjacent fields, and Holywell also, for similar reasons, grew in size about the same period. Near Abergele the old mines of Tyddyn-Morgan (p. 31) were in full work about a century and a half ago.

A vivid description of the workings on the Llyn-y-pandy and Bryn-celyn Lodes in 1798 is furnished by the Rev. Richard Warner of Bath,[1] an interesting fact being his mention of the European war then raging and its effect in closing the market for lead (p. 82).

A fabulous amount of lead and zinc ore was formerly got from the mines in the Llanarmon District. The famous Minera Mines have been worked at intervals from very early days. The mines were flourishing in 1766, at the time when it was decided to drive the day-level. Since that date their history is well known.

Smelting-works have been established from time to time locally, as at Llanerch-y-môr, Bagillt, Connah's Quay, Flint, Hawarden and other places, but those at Bagillt and Connah's Quay are the only ones still in operation. Much of the dressed ore is now sent further afield—to St. Helens, South Wales, etc.—for treatment.

Some further details of the histories of the mines will be found in the following chapters.

Outline of Geology.

The different members of the Carboniferous Limestone and Cefn-y-fedw Sandstone ('Millstone Grit') Series vary considerably when traced from point to point, and some necessary details of their variations are given in later chapters.

These rocks, which contain the majority of the lead and zinc veins dealt with in this memoir, have been described by G. H. Morton.[2] His valuable papers were published about the

[1] 'A Second Walk through Wales,' Bath, 1798, pp. 249–253.

[2] 'The Carboniferous Limestone and Cefn-y-fedw Sandstone of Flintshire.' *Proc. Liverp. Geol. Soc.*, vol. iv (pt. 4, 1883), p. 297, vol. iv (pt. 5, 1883), p. 381. Reprinted in 8vo., *Liverpool*, 1886. Also 'The Carboniferous Limestone and Millstone Grit of North Wales.' *Proc. Liverp. Geol. Soc.*, vol. iii (pt. 2, 1876), p. 152, vol. iii (pt. 3, 1877), p. 299, vol. iii (pt. 4, 1879), p. 371. Reprinted as 'The Carboniferous Limestone and Cefn-y-fedw Sandstone of the Country between Llanymynech and Minera, North Wales,' 8vo., *Lond.*, 1879.

time that the six-inch geological survey of the area north of the Bala Fault was in progress. The results of that survey are embraced in the maps and the two relative memoirs [1] published in 1885 and 1890, to which we must refer the reader for details. Between 1910 and 1915, a six-inch revision of the Flint and Denbighshire Coalfield was in progress, and included the Carboniferous Limestone area south of the Bala Fault, but the results have as yet only been published in abstract in the Summaries of Progress.[2] The six-inch maps are deposited in the Library, for public reference. The following is a brief resumé of the geology.

The Carboniferous Limestone Series unconformably overlies the shaly and slaty rocks of Ordovician and Silurian age, which were folded, cleaved and denuded before the deposition of the Carboniferous rocks. Subsequent movements have destroyed the original arrangement of these latter rocks, which now occur in three main areas, for which the subdivisions shown on p. 5 may be adopted.

1. *Vale of Clwyd.*—In general structure the Vale of Clwyd (Fig. 1, p. 6) resembles the larger Vale of Eden. In both a great fault, running a little west of north, has thrown down the Carboniferous rocks westwards far below the general level of the platform of Lower Palaeozoic strata upon which they rest, and in both cases the synclinal trough thus produced has subsequently received great deposits of red sand of New Red Sandstone age. In the Vale of Clwyd this fault separates the Vale proper from the Clwydian Hills, which bound the eastern side of the Vale, and consist of the older rocks, off which the Carboniferous rocks dip north-eastward and eastward on its eastern flank and form the second of the areas mentioned in the Table.

On the west side of the Vale the Limestone forms a conspicuous range, much broken, however, by north-and-south faults, each throwing down the strata to the east, except at the very head of the Vale. The dip swings round, with the strike, from a northward to a north-eastward or eastward direction as the outcrop is followed southward. On the east side of the Vale the great continuous line of fault (the Vale of Clwyd Fault) throws the Carboniferous rocks, and, as is believed, the New Red Sandstone also, against the older strata, the Limestone appearing at intervals in long strips, but so narrow as to form insignificant features. In these strips the dip is usually westward.

The total thickness of the Carboniferous Limestone Series near the head of the Vale is approximately 1,270 feet, as compared with about 2,880 feet in the area east of the Clwydian Hills.

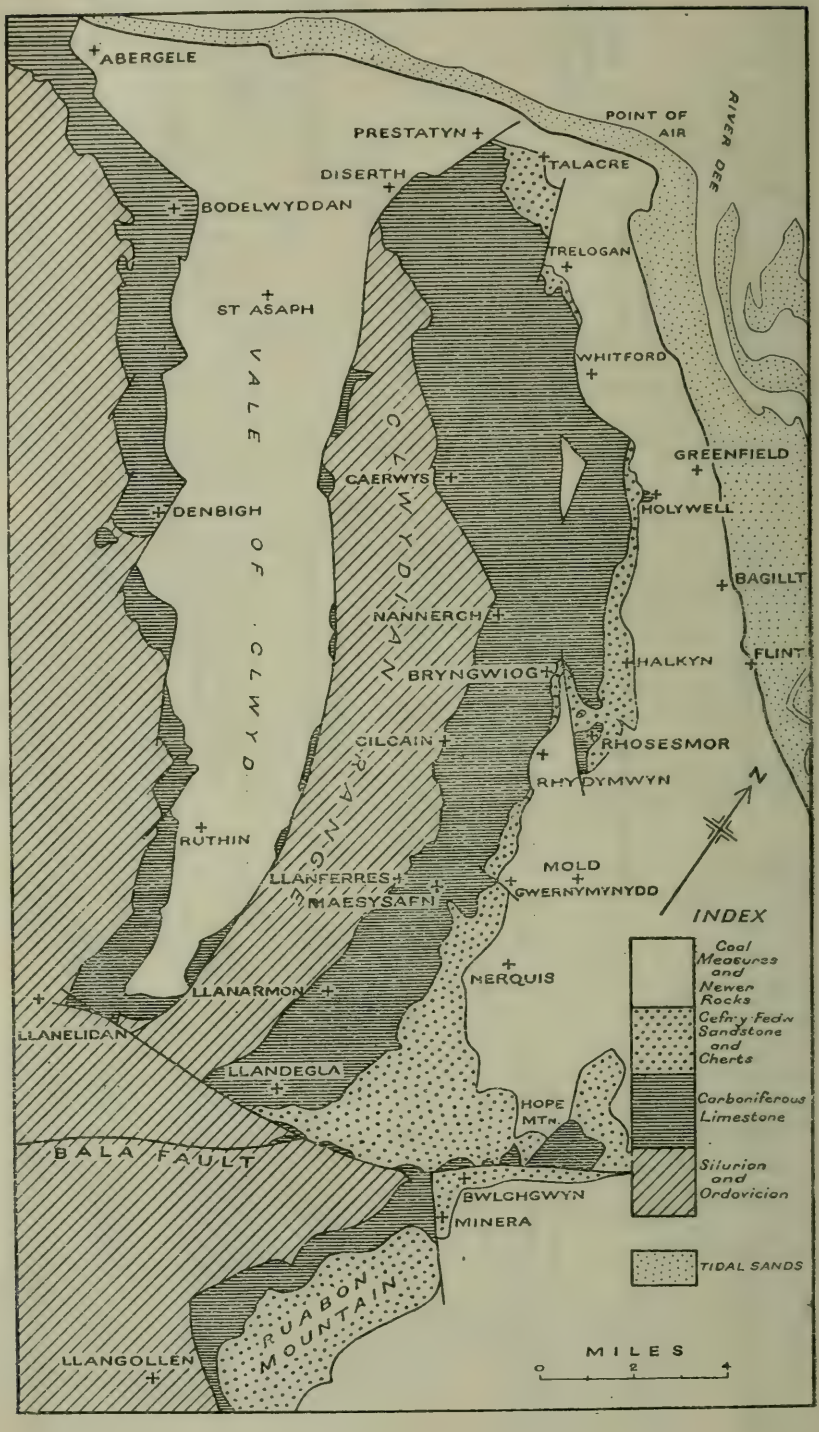
---

[1] 'Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn' (*Mem. Geol. Surv.*), 1885. 'Geology of the Neighbourhoods of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890.

[2] 'Summary of Progress' for 1910 to 1915 (*Mem. Geol. Surv.*), 1911 to 1916.

	Area 1.—Vale of Clwyd.	Area 2.—Prestatyn to Hope Mt.	Area 3.—Minera to Llanymynech.
Middle Coal Measures	— ...	Middle Coal Measures	Middle Coal Measures.
Lower Coal Measures	Purple sandstones and shales.	Gwespyr Sandstone / Holywell Shales	Holywell Shales (Minera).
Millstone Grit	—	—	? Aqueduct Grit (Trevor).
Cefn-y-fedw Sandstone	?	Cherts (N. Flint); sandstone and chert (S. Flint and Denb.)	Sandstones with cherts.
Carboniferous Limestone Series — Sandy Limestones		Black ('Aberdo') Limestone (N. Flint); Sandy Limestone Group (S. Flint and Denb.).	Sandy Limestone Group.
Carboniferous Limestone Series — Upper Grey Limestone ...		Upper Grey Limestone	Upper Grey Limestone.
Carboniferous Limestone Series — White Limestone		White Limestone	White Limestone (absent on the Berwyns and partly so at Minera and Fron).
Carboniferous Limestone Series — Lower Grey and Brown Limestone.		Lower Grey and Brown Limestone	Lower Grey and Brown Limestone (absent at Minera, Fron, and the Berwyns; probably in part at Llanymynech also).
Carboniferous Limestone Series — Basement-Beds		Basement-Beds	Basement-Beds (Shales at Llanymynech).

FIG. 1.—*General Map, Abergele to Llanjollen.*



2. *Prestatyn to Hope Mountain.*—The second area (Fig. 1, p. 6) extends from the coast near Prestatyn and Dyserth along the eastern side of the Clwydian Hills as far south as the Llanelidan branch of the Bala Fault south of Llandegla, and thence north-eastward along the north side of the Bala Fault to Hope Mountain near Caergwrle. In this district the dip of the rocks, at first in a north or north-eastward direction, swings round to an eastward one near Llandegla, and the rocks are broken by numerous strike and transverse faults. The Cefn-y-fedw Sandstone Series is overlain by the marine Lower Coal Measures (Holywell Shales), which, near Rhydymwyn, are believed to overlap the Sandstone Series for a distance of $1\frac{3}{4}$ miles, and to rest directly upon the Limestone. At Hope Mountain the highest Carboniferous Limestone and the Cefn-y-fedw Sandstone are brought up by an anticline, and form an inlier situated from 4 to 5 miles east of the main outcrop.

3. *Minera to Llanymynech.*—The rocks in this area (Fig. 1, p. 6) form a long strip, with general easterly dip, and broken by cross-faults. The Red Basement-Beds, which are fully developed in the trough of the Dee Valley basin north of Llangollen, are overlapped northward and southward by the Lower Grey and Brown Limestone. Northward these lower limestones are progressively overlapped, until the upper part of the White Limestone rests directly upon the older Palaeozoic rocks near Minera. Southward there is a similar progressive overlap, culminating near Oswestry, on the axis of the Berwyn dome, where the Upper Grey Limestone rests directly upon the old rocks. Farther southward, however, lower members again appear, and at Llanymynech Hill most of the series is present in an attenuated condition. The Basement-Beds at this spot consist of some 60 feet of shales of a local type found nowhere else in North Wales.[1]

The Cefn-y-fedw Sandstone persists throughout; and east of Llangollen the local overlying felspathic Aqueduct Grit may in part represent the true Millstone Grit of the Pennines. The Holywell Shales have been detected south of the Bala Fault near Minera, but are absent farther south, the succeeding formation being the Middle Coal Measures.

The Ores: Character, Distribution, and Origin.

The lead and zinc ores with their associated minerals are restricted to the Carboniferous Limestone Series and the Cefn-y-fedw Sandstone Series with one exception, namely, at the old Bryn-celyn Mine (p. 80), near Rhydymwyn, where ore was worked in the Lower Coal Measures. They occur sparingly, or are absent, in the Lower Grey and Brown Limestone and Basement-Beds.

[1] 'Summary of Progress' for 1915 (*Mem. Geol. Surv.*), 1916, pp. 6, 7.

The following ores are raised, or have been raised in the past:—

Galena, in part argentiferous	PbS
Cerussite or White Lead	$PbCO_3$
Anglesite? (rare)	$PbSO_4$
Blende or Black Jack	ZnS
Calamine, Caulk or Coke	$ZnCO_3$

With these are associated:—

Copper pyrites or Chalcopyrite, in small quantities only	$CuFeS_2$
Malachite (rare)	$CuCO_3.Cu(OH)_2$
Pyrolusite or Wad (rare)	MnO_2
Barytes	$BaSO_4$
Fluorspar	CaF_2
Quartz	SiO_2
Calcite	$CaCO_3$

Veins and Cross-courses.—The ores of lead and zinc occur in lodes, which, in the area north of the Llanelidan and Bala Faults, have a definite arrangement in two sets[1]: one mainly east-and-west, referred to as 'veins,' and the other north-and-south, referred to as 'cross-courses.' In most cases the east-and-west veins occupy transverse fault-lines that traverse the outcrops nearly at right-angles and shift the strata considerably, and can, therefore, be detected by surface-mapping. The veins near the Bala Fault have a south-eastward trend. The cross-courses, on the other hand, usually occupy faults of slightly later date than the east-and-west faults, which they displace, though only to a slight extent. They usually follow, or are but slightly oblique to, the strike of the Limestone and Cefn-y-fedw Sandstone, and are therefore not easily detected at the surface. In North Flintshire, however, where the strike of the beds swings round westward, the cross-courses become in consequence transverse to the strike, and are more easily detected, whilst the east-and-west faults become almost strike-faults, which near Dyserth trend from north-east to south-west. North of the Nant-figillt Fault (Fig. 6, p. 71) the majority of the veins throw down southward. South of it the majority throw down northward.

South of the Bala Fault the chief veins, *e.g.*, near Minera, trend from north-west to south-east, and in their contents resemble the east-and-west veins of the district north of the Bala Fault. Other veins run nearly east-and-west, whilst some cross-courses run north-and-south.

The veins differ from the cross-courses in their mineral content as well as in direction.[2] They contain blende and galena, the latter with a proportion of silver ranging up to 14 ounces, or very rarely up to 18 ounces, per ton. The galena is often laminated. The cross-courses, on the other hand, contain

[1] *See* six-inch geological maps deposited in the Library of the Geological Survey, Jermyn Street, London.

[2] 'Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, p. 160.

no blende and are poorer in silver, but frequently show copper pyrites in small specks or needles. The galena is more earthy than that in the veins.

The spars also in the two sets of lodes can be distinguished by the miners; those of the east-and-west veins being often largely made up of silica associated with crystalline calcium carbonate in a form known as 'tuft' (more especially in the neighbourhood of the Chert Beds), whilst the cross-courses in the majority of cases contain yellow clay, in which large masses of calc-spar and galena lie embedded; they are often empty or in communication with large empty caverns or 'vughs,' and appear to form the principal underground water-channels.

Hunt[1] states that near the ore calc-spar takes the pale tint much prized by miners, who call it 'bearing-spar,' and similarly the cherts, generally black, take, in the productive region, a bluish tint, often very clear and with a translucent appearance quite characteristic. This is known by the miners as 'bearing-chert.'

In those lodes which are transverse to the strike of the beds, the ore tends to occur in 'runs' or 'shoots,' following the dip of the beds, especially at those points where the faults traverse rocks of a texture suitable for the development of an open fracture; the 'runs' tend to pinch out or disappear in shaly ground. It is beneath beds of shale that many of the veins are most prolific.

In some mines cerussite, calamine and fluorspar are associated with the veins, and barytes has been recorded in a few instances.

Flats.—A large quantity of galena has been raised from a form of cavity known to the miners as 'flats.' Many of the flats seem to correspond rather with pipe-veins than with the flats as known in Derbyshire. In those which were accessible in 1879, at the time of the resurvey,[2] the ore lay as an irregular 'bed' (in contradistinction to a vertical rib) in a mass of calc-spar that filled caverns along a north-and-south joint or crack in the limestone (p. 76).

In another form of 'flat' the 'pipe' or 'run' containing the ore follows the junction of a band of limestone and sandstone, from which circumstance the Sandy Limestones of the vicinity of Mold have acquired the name of the flat-bearing beds or 'flat-measures' among the miners. Sometimes, as in the Jamaica Mine (p. 94), the limestone has perished altogether to a depth of many yards, and its place has been taken by sand, clay, and disintegrated sandstone, containing masses or 'beds' of galena. Flats, whether in limestone or in calcareous sandstone, appear to have been formed in channels hollowed out by underground waters, but the ore in them may in some cases be the result of rearrangement and concentration by circulating

[1] 'British Mining,' 8vo., *Lond.*, 1884, p. 323

[2] *Op. cit.*, p. 183.

waters[1]; they follow no known fault, but occur in the neighbourhood of vertical joints, and run down the dip-slope of the strata, probably keeping to the most soluble limestone. They prove to be of less persistence than the east-and-west veins, and occasionally contain blende.

Flats in the Cherts are of a slightly different character, being chiefly due to the shattering of the brittle cherts along the fault-lines, and to their occasionally bent and folded character, which is in part an original feature. At East Pant-y-gôf Mine (p. 130), for example, the ore in a broad belt, forming the vein, occurs as curved plates following the folds, and as vertical and inclined ribs in the shattered zone. Flats in the Chert tend to occur, and to be most prolific, at the junction of a vein with a cross-course.

Gravel-ore.—Gravel-ore is a name applied by the miners to the loose lumps of galena that occur in the soil or in the Glacial deposits along the back or outcrop of a lode. In the Talargoch Mine (p. 40) a great quantity of ore occurred in this form; and the surface-courses of many veins and the outcrops of flats are marked by clusters of mine-hillocks formed in search of gravel-ore.

Distribution of Ore in detail.—Considering the lodes in detail, it seems that where blende and galena occur together in a shoot of ore, the blende is usually found at all levels; but there is a tendency for the galena to die out in depth, leaving blende as the principal ore. Talargoch, Talacre, and Minera mines furnish good examples of this tendency. In some cases the galena is most abundant at the middle levels in a lode. The distribution of silver does not appear to be governed by any very definite rule, varying in amount in different veins between 0 ounces and 18 ounces per ton of galena. In Powell's Lode (p. 137) the brittle ore at the west end of the mine contained 3 ounces per ton, whilst the steel-ore at the east end contained from 6 to 8 ounces per ton. Again: at the west end of the East Pant-y-gôf Lode (p. 130) silver averaged 4 ounces per ton, which increased to 7 ounces per ton at the east end. At Pant-y-mwyn, in the course of the new work, the silver averaged 5 ounces per ton in 1905, but fell to $3\frac{1}{2}$ ounces in 1908, and later increased again to 4·425 ounces in 1914. At Minera, silver averaged a little over 4 ounces at the west end and a little under 4 ounces at the east end; the average percentage of silver from the ore raised in the Denbighshire Mines since 1853 is less than that from the Flintshire mines (Pls. I and II). There is a suggestion, borne out to some extent by the curves (Pls. I and II), that the amount of silver in any lode may increase with the depth.

[1] A. M. Finlayson, 'Problems of Ore-Deposition in the Lead and Zinc Veins of Great Britain.' *Quart. Journ. Geol. Soc.*, vol. lxvi, 1910, p. 299. *Vide* p. 303.

Cerussite and calamine appear as decomposition-products chiefly in either the higher parts of a mine, or at the western ends, towards the rise in the strata. Calamine does not occur commonly in the Cherts. In one case (Llyn-y-pandy, p. 82), cerussite definitely occurred on the footwall, with galena on the hanging wall of the lode. Cerussite occurs most commonly in the east-and-west veins. A green lead-ore (? anglesite) was got formerly from the Silver Rake (p. 62).

Copper pyrites occurs as needles and small crystals in calc-spar on the north-and-south cross-courses, and a little malachite is reported from the East Pant-y-gôf Lode. Manganese dioxide ('wad' or 'blacking') occurred in flats at the North Hendre Mine.

Fluorspar occurs chiefly in some, but not all, of the 'veins' near Halkyn, generally near the western ends of the veins. The Great Halkyn Lode, for example, contains fluorspar, whilst the East Pant-y-gôf Lode has none (pp. 133, 134).

Barytes occurred at Bryn-gwiog; in the Great Halkyn Lode; in the Maes-y-pwll Lode, and at one or two other spots.

Regional Distribution.—The regional distribution of the lead and zinc ores is of interest. The productivity is greatest in the areas (1), from Prestatyn and Dyserth to Holywell; (2), from Holywell to Llanarmon; and (3), south of the Bala Fault, near Minera. Ore occurs more sparingly on the west side of the Vale of Clwyd near Abergele and St. Asaph, and in the Limestone between the Minera Mines and Llangollen. Outside these areas the occurrences are sporadic.

The zone of heaviest mineralization in North Flintshire occurs in the highest part of the Limestone Series and in the overlying Cefn-y-fedw Cherts, beneath the thick Holywell Shales. Farther south it appears to descend to lower horizons; in the Llanarmon area, for example, ore appears to have been prolific in the massive middle or White Limestones, as well as being fairly abundant in the Upper Grey and in the Sandy Limestones. Though the eastern part of this belt has not yet been thoroughly explored, it is possible that good runs may be found in the highest limestones, but the overlying Cefn-y-fedw Sandstone appears to carry ore more sparingly.

South of Bôd-Idris, near Llandegla, however, and all along the north side of the Bala Fault, including Hope Mountain, ore is scarce or practically absent, whilst it occurred freely south of the fault near Minera in fairly high Limestone and in Limestone faulted against Cefn-y-fedw Sandstone. Farther south, on the Eglwyseg Rocks, ore occurs at lower horizons.

Origin and Date of Formation.—In the whole of this heavily mineralized belt the underlying Ordovician or Silurian rocks are, with a few exceptions, barren, yet accepting provisionally

the theory[1] that the minerals were introduced into the Carboniferous rocks from below by magmatic solutions from deep-seated sources, these pre-Carboniferous rocks must have been traversed by the solutions in their upward passage. It may be that the rather tightly-closed faults up which the solutions came were not suitable for deposition of ore at the temperatures that reigned, and it was only when the solutions entered the much more open fissures of the Carboniferous Limestone and Cefn-y-fedw Sandstone that conditions became suitable for deposition. These conditions were probably favoured also by the chemical composition of these rocks.[2]

From a study of sections along veins there is a suggestion that the plane above which primary crystallization of blende and galena took place was once nearly horizontal, but has received a subsequent slight tilt in the direction of dip of the Limestone, and that, to the rise, the mineralized belt has been denuded away. Runs of ore occur at shallow depth at the western ends of 'veins,' but plunge deeper at the eastern ends (Fig. 13, p. 95 and Pl. III). This tilt was of about the magnitude of the tilt of the Triassic deposits of the Vale of Clwyd and the Cheshire Plain; and since we have reason to believe that this movement was intra- or immediately post- Triassic, it is possible that the date of mineralization lies between Carboniferous and Triassic times, a conclusion arrived at independently by Finlayson[3], and supported by the supposed occurrence of secondary galena in the Triassic deposits of Alderley Edge.[4]

As previously pointed out, the majority of the cross-courses were of slightly later date than the veins, and presumably the minerals deposited in them were also formed at a later date than those in the veins. Still, we may consider the two stages to be almost contemporaneous, the second upward movement of mineral solutions into the cross-courses occurring at a slightly later stage in the differentiation of the igneous magma that must underlie the region.

The infilling of cavities along the faults was accompanied by a certain amount of metasomatic replacement of re-crystallised limestone by galena and quartz.[5] Limestone charged with small doubly-terminated quartz-crystals has been noticed by the present writer among the waste-stuff raised at Moel-y-Crio and in the vein-stuff at the Hendre Mine, and was probably produced by this action, which also accounts for the

[1] A. M. Finlayson, 'Problems of Ore-Deposition in the Lead and Zinc Veins of Great Britain,' *Quart. Journ. Geol. Soc.*, vol. lxvi, 1910, p. 299; also 'The Metallogeny of the British Isles,' *Ibid.*, p. 281; *vide* pp. 288, 295. Also W. H. Goodchild, 'The Evolution of Ore Deposits from Igneous Magmas,' *Mining Mag.*, vol. xviii (Jan.–June, 1918), pp. 135–141.

[2] A. M. Finlayson, 'Problems of Ore-Deposition,' *op. cit.*, pp. 321–3.

[3] 'The Metallogeny of the British Isles,' *op. cit.*, pp. 287, 288.

[4] H. Dewey, in forthcoming Special Report on Copper-Ores (*Mem. Geol. Surv.*).

[5] Finlayson, 'Problems of Ore-Deposition,' *op. cit.*, p. 310.

occurrence of similar crystals in the sand raised from the Pant Lode at the Caeau Shaft (p. 123).

The function of beds of shale or of shaly limestone in determining deposition of ore has been important. It is found, for example, that veins and flats are often richest beneath a cover of shale in which the fault tends to become pinched out or filled with pugged material. Whether, in a dipping series of alternating shales and limestones, the mineral solutions passed vertically through bed after bed of shale or shaly limestone and left their quota of ore as 'runs' (Pl. III) in each intervening bed of pure limestone,[1] or whether the rise of solutions was updip along the fissures in the direction of the rise of the strata, is not clear. Both processes may have operated, and the second was probably subordinate to the first. The first process must have operated in the case of the rise of solutions through fissures in the Silurian and Ordovician rocks beneath the Limestone. It seems probable, however, that certain fault-lines acted as barriers to the rise of solutions, just as they do to the passage of vadose waters (the staircase or chessboard movement of solutions would take place in the upward instead of downward direction ; *see* p. 22). The Llanelidan-Bala Fault, which is inclined northward, consists in general of a broad belt of pugged shale in which Silurian and Ordovician rocks are crushed against each other, either at the surface or at comparatively shallow depth. This inclined plane might act as a screen to vertically-rising solutions, which would accumulate rather on the south, or underside, than on the north, or hanging side, and may furnish the reason why the area north of this fault is comparatively barren for a distance of from one to two miles, whereas the rocks south of it, near Minera, are rich in ore. This conception gathers weight when we recall that practically none of the really great faults of this region—the Vale of Clwyd Fault, the Bala and Llanelidan Faults, and the Vale of Llangollen Fault—though belts of intense crushing, are themselves ore-bearing; the smaller faults, from their more normal character, evidently functioned more readily as carriers of magmatic waters. The faults in the Carboniferous rocks are all based upon previous movements that affected the older rocks and were repeated at a later stage.

Order of Deposition and Secondary Alteration.—As regards the general order of original deposition of the minerals from below, we may accept that postulated by Finlayson[2] as being: chalcopyrite, fluorspar, blende, galena, with barytes contem-

[1] In the ancient mines of Laurium, Attica, argentiferous galena and blende were found to be deposited, in diminishing richness, by solutions rising from below, in a triple succession of thick limestones separated by shales. *See* C. B. Wedd and G. C. Drabble in 'The Fluorspar Deposits of Derbyshire,' *Trans. Inst. Min. Eng.*, vol. xxxv, 1907–8, excerpt pp. 23, 24.

[2] 'Problems of Ore-Deposition,' *op. cit.*, p. 320.

poraneous with the last two; but it seems clear that we are dealing with two episodes. In the first suite were fluorspar, blende, galena, and barytes; in the second chalcopyrite, galena, and possibly barytes.

Secondary changes have given rise to occurrences of cerussite and calamine, and possibly also to depletion of some of the galena in silver, with secondary enrichment at other points, but further evidence on this point is wanting. It does not seem necessary to assume, with Finlayson, that the silver-content of the original galena was much higher than it is at present, for it is appreciably higher than that in the galena obtained from the Ordovician rocks of the Shropshire mines in the Minsterley district.

Although secondary deposition of galena and blende by circulating surface-waters may have, and probably has, occurred in some of the flats and pipes, and locally in vughs, no great amount of movement of ore attributable to this cause seems to have taken place. The chief argument against such secondary deposition is the general absence of blende and calamine in the cross-courses, which are now the chief carriers of underground waters, and which must have been functioning in this way since at least Triassic times. A large group of cross-courses near Holywell, cutting important veins bearing blende, are themselves devoid of this mineral. This would hardly be possible if any great secondary solution and redeposition of blende had taken place.

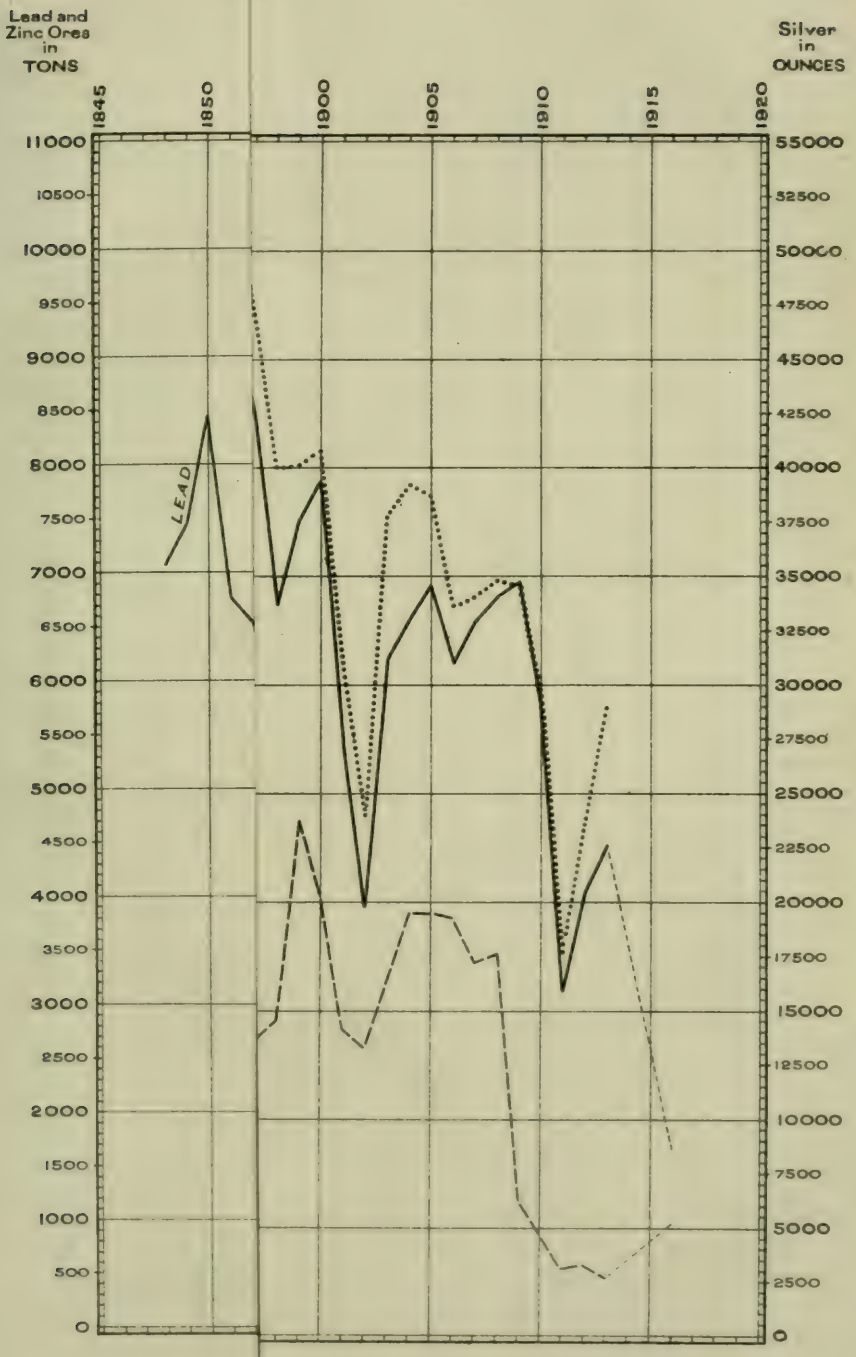
Output.

The number of mines that have raised ore from areas dealt with in this report is considerable; many of them, however, had quite a short life, and were more of the nature of trials than permanent mines. Detailed statistics of output have been collected and published by the Geological Survey from 1848 to 1881, and by the Home Office from 1882 to 1913. Some of these details have been incorporated in the descriptions of the mines and veins given in succeeding chapters.

The graphs (Plates I and II) give the total output of lead, zinc and silver in the counties of Flintshire and Denbighshire for the years 1848 to 1916 inclusive.

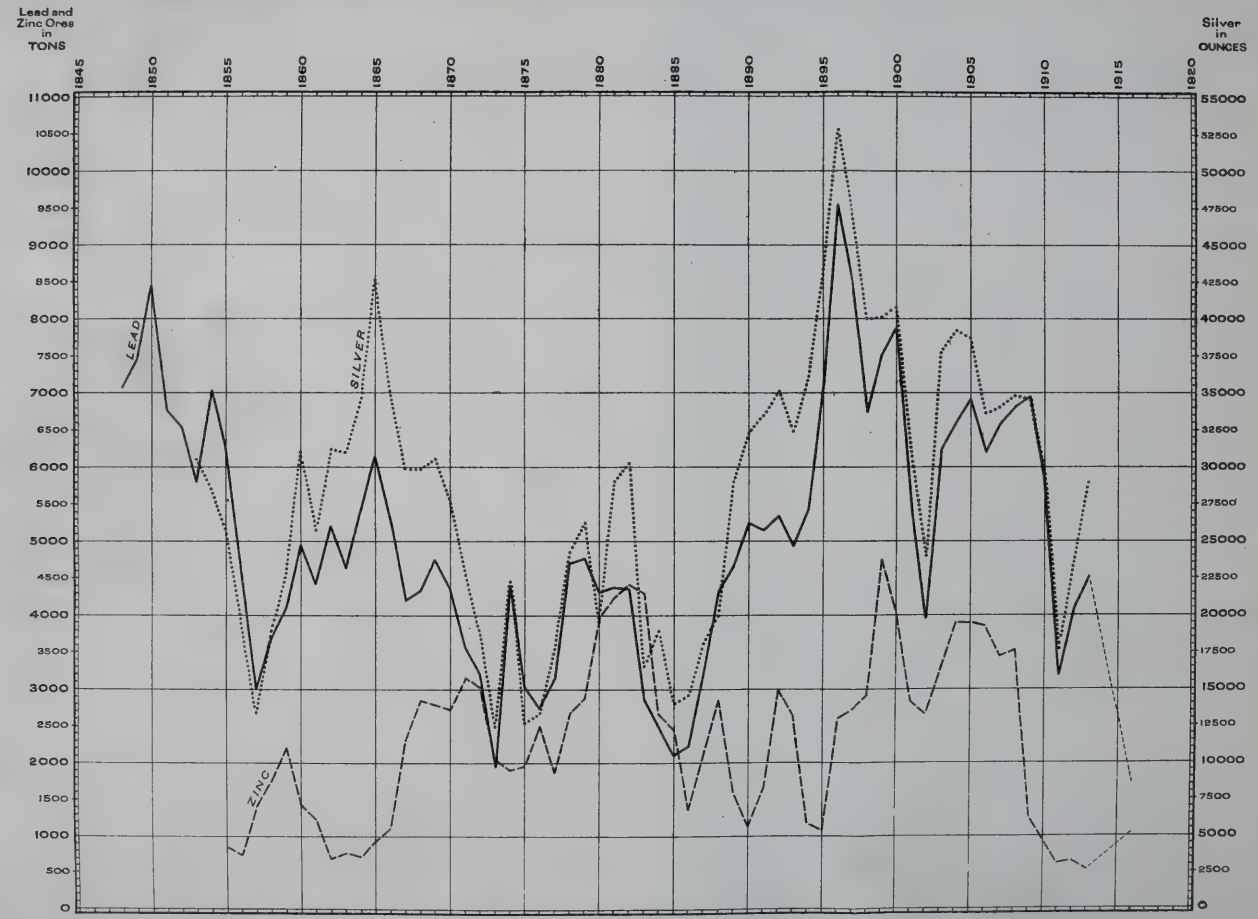
In commenting upon the above diagrams, we note that in Flintshire there are five maxima of lead-ore production. The chief mines operating in 1850 were Talargoch, Hendre and Maes-y-safn, Dingle and Deep Level; and in 1865 Talargoch, Bryn-gwiog and Rhosesmor; whilst the period from 1875 onward saw the commencement of the driving of the Halkyn Tunnel and the revival of the mines. In 1886, North Hendre

Out16.



London: Stanf. 61/603. 750. 4

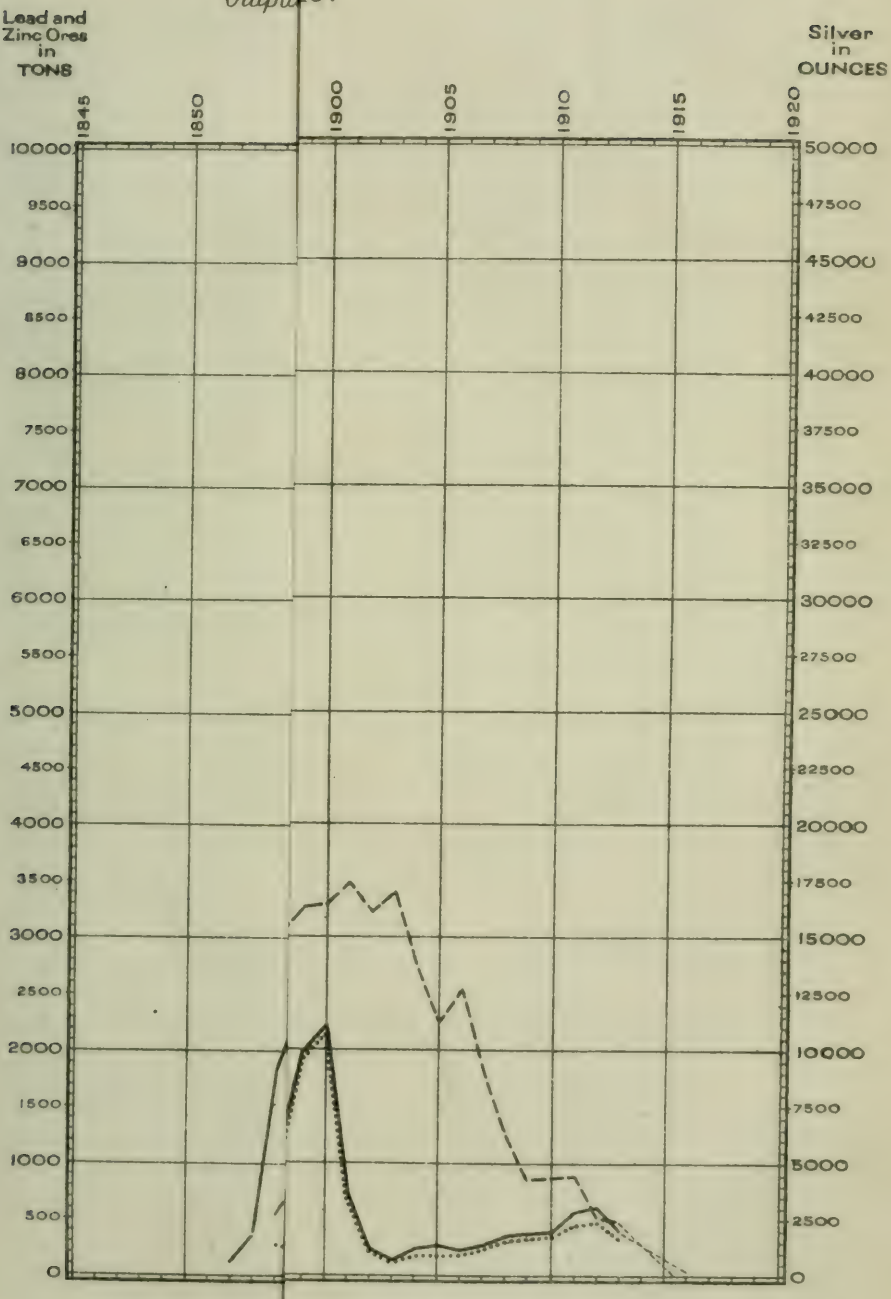
Outputs of Lead (Argentiferous) and Zinc Ores in Flintshire from 1848 to 1916.



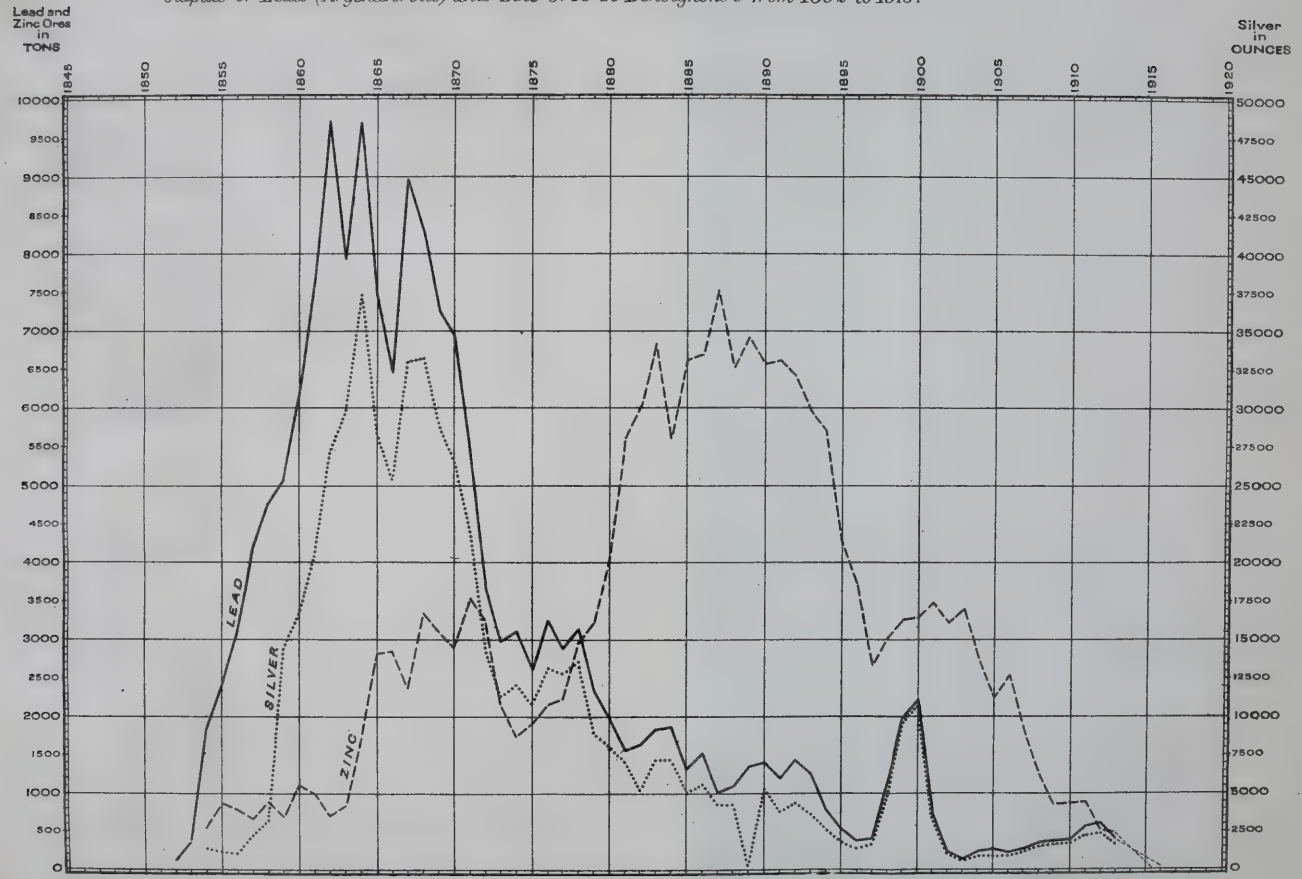
10200 3m 73 6/663. 750. & 21.

Malby & Sons, Lith.

Output 16.


Lead and Zinc Ores in TONS
Silver in OUNCES
1845
1850
1900
1905
1910
1915
1920
10000
9500
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
50000
47500
45000
42500
40000
37500
35000
32500
30000
27500
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
0

Outputs of Lead (Argentiferous) and Zinc Ores in Denbighshire from 1852 to 1916.



and Halkyn had large outputs, whilst from 1905–1909 Rhosesmor, Halkyn and North Hendre were the chief contributors.

Lead-mining in Denbighshire during the whole of this period is tantamount to lead-mining at Minera, the curves illustrating the outputs being similar in the two cases (*cf.* Pl. II and Fig. 16, p. 111).

The amount of blende raised before 1870 appears to have been small as compared with that of galena ; but after that date, in both counties, it became of more importance, partly owing, no doubt, to its increasing value, and partly because many of the veins contained at a depth relatively more blende than galena. This point is emphasized in the curves for Denbighshire, which are a reflection of those of the Minera Mines (Fig. 16, p. 111), the chief producers in the county. It is interesting to note, further, that when mining of lead was at a low ebb (*e.g.* in the 'seventies' and 'eighties'), that of zinc was correspondingly greater, and the curves tend to approach each other.

The amount of silver obtained from the ores in Flintshire was relatively greater than that obtained from Denbighshire (chiefly Minera), but the average proportion of silver to galena in each case is fairly constant, that for Flintshire showing the greatest variation from the normal, which is justified by the greater number of mines represented in the curves, and the wider variation in the silver-content of the ores.

The year 1856 gave the highest recorded output of dressed lead-ore for the whole country. At this date two mines were operating in Denbighshire, and produced 3,103 tons 15 cwts. of dressed ore, containing 1,034 ounces of silver In Flintshire, 39 mines were in operation with an output of 4,607 tons 5 cwts. of dressed ore yielding 19,340 ounces of silver. In 1916, only one mine was at work in Denbighshire, with an output of 3 tons of dressed lead-ore, whilst 8 mines in the Halkyn district of Flintshire produced 1,703 tons.

The year 1881 gave the highest recorded output of zinc-ore for the whole country. In Denbighshire, 5 mines produced 5,602 tons, valued at £21,482, whilst 4 mines in Flintshire produced 4,233 tons of ore, valued at £13,839. In 1916, the Denbighshire mines produced practically no zinc-ore, whilst Rhosesmor and Halkyn Mines in Flintshire returned between them only 1,013 tons of ore.[1]

When deeper drainage has been secured in the Halkyn district it is estimated[2] that the following monthly outputs will

---

[1] 'Report of Controller of the Department for the Development of Mineral Resources in the United Kingdom,' *Min. of Munitions*, White Paper, 1918, pp. 15–19.

[2] By Captains Matthew and J. Francis, Halkyn Mines.

be obtained—an annual total of roughly 18,240 tons of lead-ore, in addition to a large quantity of blende.

Mine	Estimated Monthly Production in Tons
1. New North Halkyn 2. Halkyn 3. Mount Halkyn 4. Bryn-gwiog Mines, Ltd.	175
5. East Halkyn	200
6. North Hendre	170
7. South Halkyn: Garreg-boeth, 200 Bryn-celyn, 100	300
8. Llyn-y-pandy	200
9. Pant-y-mwyn 10. Bwlch-y-ddaufryn 11. Pant-y-buarth 12. Cat Hole	475

The drainage effected by the Halkyn Tunnel led to the mines being resuscitated one by one and yielding about 20 per cent. of the whole British output in lead, and it is hoped that a proportionate rise in output will follow upon the completion of the new deep drainage scheme (p. 26).

Unproved tracts of ground, which will be explored by the deeper tunnel, occur between the Pant-y-mwyn and the Cat Hole Mines. These may contain lodes which, like Powell's Lode (p. 135), make little or no show at the surface, but should add materially to any estimated output. Furthermore: to the south also of the Cat Hole Mine there is much unproved ground in the eastern belt of Limestone, which there are reasons for assuming may prove to be fairly, possibly highly, productive. In this area certain veins have yielded ore of the following values[1] in the past: Pant-du, £850,000; Belgrave, £900,000; Nant and Bog, £2,000,000; and Pant-y-gwlanod, £300,000.

From most of the larger veins in this southern area a fair monthly output was maintained up to the time they ceased to be worked owing to water, maintenance charges and the low price of ore, and rich courses of ore were reported in the lower levels up to the last. The proposed Sea-level or Milwr Tunnel (p. 26) would unwater the mines about 300 feet below their present level. It is estimated that thereby an output of at least 1,200 tons of ore a month might be got; making, with that given above on the same authority, a total annual output of 32,640 tons of lead-ore, in addition to some 4,000 to 5,000 tons of blende, for the Halkyn and Llanarmon districts. Even this output might be secured if the Llanarmon District Mines Drainage scheme (p. 28) were undertaken. The chief veins or

[1] Figures by Mr. George Hughes, aforetime agent to the Duke of Westminster.

flats affected in this southern area would be : the Gwern-y-mynydd flat, the Fron-isaf fork of the Cat Hole Lode, the Coed-Cynric and Coed-y fedw lodes, the Mount Pleasant flat, the Maes-y-safn lode, the Jamaica flat, the Pant-du, Pentre-hobin, and Goodwin's lodes, the East Pant-du flat and the Pant-du lode, the Taylor's and Belgrave lodes, and the Blaen-y-nant, Bog, Nant and Pant-y-gwlanod lodes.

Farther north, in the Holywell District, veins cut by the Milwr Tunnel, and also the mines unwatered as a result, await capital for development (pp. 118–124).

A boring for water at Abbey Mills, Greenfield, near Holywell, put down in 1917–18, after passing through Glacial drift and Middle and Lower Coal Measures to a depth of 945 feet, entered a fault-rock, consisting of 43 feet of thin-bedded black chert, brecciated and veined with galena-bearing calcite and specks of copper pyrites and iron pyrites. This overlay Carboniferous Limestone, proved to a depth of 1,194 feet. "As an attempt " to obtain water the borehole was a failure, but it has " much significance in other respects. The bodies of galena " which have been so prolific on Halkin Mountain occur in " veins, but tend to follow the intersection of a vein with certain " strata. . . . The old workings were carried to the bottom " of these productive beds under Halkin Mountain, and failure " to find ore at greater depths vertically led to a belief that " deep mining was useless in Flintshire. The ore-bodies, " however, could not be followed far down their inclination " eastwards, and there remains a possible but unproved lead-" field under the cover of Coal Measures in that direction. " . . . . It was clear . . . . that there existed a " possibility that the chert and limestone which underlie the " Coal Measures might prove to contain productive veins. " The Abbey Mills boring is the first exploration that furnishes " evidence on this point. That the boring passed through a " fault is certain, and that the fault belongs to the north-and-" south system is probable, for all the faults proved, or inferred " to exist, in the neighbourhood of the hole, belong to that " system. The existence of specks of copper-pyrites in the " fault-rock supports this hypothesis, for that ore frequently " occurs in the north-and-south cross-courses of Halkin " Mountain, but is exceptional in the east-and-west veins."[1]

In the Minera District no great development is likely in the near future unless the price of blende justifies the expenditure of a large sum of money to unwater the mines, or to drive a deeper adit from the lower ground of the coalfield (p. 29). The large output of the Minera Mines during part of last century is dealt with on pp. 111, 112, and Fig. 16.

[1] ' On a Boring at Abbey Mills, Holywell, 1917–18.' ' Summary of Progress ' for 1918 (*Mem. Geol. Surv.*), 1919, pp. 61, 62.

Analyses and Assays.

The following tables of analyses and assays of blende and galena, and of silver in the galena, have been furnished by the Halkyn Mines, Ltd.

Analyses of Blende from the Halkyn Mines, Ltd.

Analyst: Mr. A. H. Knight.

	Pant-y-gôf Lode		Great Halkyn Lode		
	I	II	III	IV	V
Zinc ... Zn	59·700	54·00	55·540	50·250	46·360
Lead ... Pb	2·360	2·110	3·025	3·450	3·950
Copper ... Cu	0·144	0·144	0·060	0·050	0·050
Cadmium ... Cd	0·368	0·370	0·220	0·242	0·264
Bismuth ... Bi	trace	trace	0·004	0·006	0·006
Iron ... Fe	0·910	0·812	0·661	0·722	0·762
Manganese Mn	0·010	trace	0·040	0·069	0·057
Calcium oxide CaO	0·800	4·120	—	—	—
Calcium carbonate $CaCO_3$	—	—	6·000	9·210	8·693
*Calcium fluoride CaF_2	nil	trace	0·950	3·400	6·800
Sulphur ... S	30·050	25·660	26·480	23·620	20·403
Silica ... SiO_2	4·790	7·112	5·640	6·680	9·300
Arsenic (As), Antimony (Sb), Phosphorus (P)	nil	nil	nil	nil	nil
Carbon dioxide (CO_2) and oxygen (O) (by difference)	0·862	5·042	(O) 1·380	(O) 2·301	(O) 3·455
Totals ...	99·994	99·370	100·000	100·000	100·100
Silver (oz. per ton) Ag	1·5	1·2	1·0	1·0	1·0
*Fluorine (per cent.) F	—	—	0·463	1·66	3·32

The gangue material of the Pant-y-gôf Lode contains little or no fluorspar, whereas that of the Great Halkyn Lode comprises a considerable amount, which is separable with difficulty. Hence the blende from the Great Halkyn Lode, more especially the lower grades, contains a relatively high proportion of calcium fluoride. The difficulty of separation of the fluorspar, by the processes employed at the Halkyn Mines, means the loss of a considerable proportion of blende, which, however, appears in the residues (pp. 19 and 134), and may possibly be extracted at some future date.

The following analyses of blende from other districts are given for comparison :—

	Great Laxey Mine Isle of Man.	Wanlockhead Mine.
Zinc	51·53	48·15
Iron	8·32	4·49
Lead	1·44	—
Lead oxide	—	3·94
Copper	0·43	—
Copper oxide	—	0·40
Antimony	0·12	—
Barium sulphate	—	7·08
Calcium oxide	0·85	1·45
Magnesia	0·60	0·40
Sulphur	31·45	27·01
Alumina	—	0·89
Silica	—	2·55
Silica and silicates	5·28	—
Fluorine	—	nil
Insol. matter	—	1·42
Moisture	—	0·06
	100·02	97·84

The following analyses of residues from the Halkyn Mines, Ltd., were obtained by Mr. Mavor from Messrs. D. C. Griffiths & Co., 7 and 8, Victoria Avenue, Bishopsgate, E.C. 2 :—

	No. 1.	No. 2.	No. 3.	No. 4 (Slimes)
Silica	36·47	—	—	—
Calcium carbonate	31·56	46·39	27·93	—
Calcium fluoride	12·28	4·29	14·52	—
Barium sulphate	nil	nil	nil	—
Zinc	8·04	3·45	6·16	4·7
Lead	1·10	0·33	1·17	4·27
Copper	0·05	—	—	—
Iron	1·24	—	—	—
Sulphur	3·55	—	—	—
Alumina	2·73	—	—	—
Manganese	0·05	—	—	—
Magnesia	0·28	—	—	—
Oxygen, alkalies, etc.	nil	—	—	—
Combined water (by diff.)	2·65	—	—	—
	100·00			
Silver (oz. per ton)	—	1·0	0·2	—
Gold (,,)	—	0·016	0·019	—

Samples dried at 212° F. Analysed, 14 Jan. 1918.

Several hundred tons of slime tailings contained about 15 per cent. of zinc. The latter, as well as the lead and silver, might be extracted by electro-chemical processes, whereby spelter would be obtained from soluble chlorides formed by the action of chlorine. Valuable by-products also might be made (p. 134).

The following assays of ores raised in the Halkyn district in recent years are supplied by the Halkyn Mines, Ltd. :—

Mine or Lode	Year	Lead in Galena (per cent.)	Zinc in Blende (per cent.)	Silver (oz. per Ton of Galena)
East Pant-y-gôf	1910	81·85	—	4·375
,, ...	,,	69·2*	—	3·925
,, ...	,,	82·1	—	4·575
,, ...	1914	—	54·4	—
,, ...	,,	—	50·0	—
,, ...	1915	—	59·435	—
,, ...	,,	—	59·785	—
,, ...	,,	—	56·925	—
,, ...	,,	—	56·0	—
,, ...	,,	—	51·0	—
,, ...	,,	82·775	—	5·925
,, ...	,,	79·15	—	6·625
,, ...	1918	83·25	—	7·075
Pant-y-gôf and Great Halkyn Lodes	,,	82·5	57·0	6·75
Mount Halkyn	1911	83·0	—	5·5
,, ...	1912	82·0	—	6·0
,, ...	1913–15	83·0	—	6·0
,, ...	1916	75·5	—	6·0
South Halkyn (Garreg-boeth Lode)	1906	—	54·0	—
,, ...	1915	79–80	—	3·75–4·0
Plâs-Winter	1914	79·7	—	8·0
,, ...	1916	78·0	—	8·0
,, ...	1917	78·0	—	7·5
,, ...	1918	77·45	—	8·375
Llyn-y-pandy	1906	82·0	53·0	4·0
,, ...	1907	82·0	—	4·0
Llyn-y-pandy (Mountain Shaft) ...	1918	81·45	—	3·925
South Llyn-y-pandy	1905	82·0	—	4·5
,, ,, ...	1907	68·0*	—	—
Pant-y-mwyn	1905	84·0	60·19	5
,, ...	1906–7	84·0	59·0	4·5
,, ...	1908	84·0	58·0	3·5
,, ...	1909	83·6	53·9	3·7
,, ...	1914	79·85	47·8	4·425

* White ore.

No blende occurs in the Mount Halkyn Mine. Lump and grain ore, of which no assays were made, were sold by the ton and exported to West Africa. Very little blende was got from the Plâs-Winter Mine.

The 'white ore' or cerussite, if present in any quantity, would lower the percentage of lead in the ores. The percentages given above are probably higher than the average for the Flintshire veins. This average is better expressed in the table printed on the opposite page, where also the directions of the veins are given. It will be noticed that the highest percentages of silver occur (with the exception of Rhosesmor and Gladstone) in veins bearing nearly east-and-west.

The following table is reprinted from the Memoir on Flint, Mold, and Ruthin (1890, p. 162); the figures in the last two columns were supplied by D. C. Davies :—

Direction and Character of the Lead-Ore of some of the Flintshire Veins.

	General Direction	Percentage of Metallic Lead	Silver to the Ton (oz. and dwt.)
Bod-Idris	E. 30° S.	78	5 12
Bryn-celyn	E. 18° N.	77–80	5 12
Bryn-gwiog	E. 5° S.	77	6 12
Cat Hole	E. 15° S.	77	5 12
Clwt-militia	E.	80	8 0 to 12
Denbigh Consolidated ...	E. 37° S.	80	5 4
Fron-fawnog	E. 25° N.	77–80	5 4
Fron-heulog	—	81	nil
Garreg-boeth	E. 17° N.	80	5 12
Gladstone	E. 25° S.	77–79	6 0 to 8
Gorsedd and Merllyn ...	E.	81	11 0 to 12
Gwern-y-mynydd	E.	77–79	5 4
Hendre, Old	E. 10° N.	77–79	8 0 to 10
Hendre, North	N.	77	5 12
Holloway	E. & E. 10° S.	82	16 0 to 18
Jamaica	?	77–79	5 4
Maes-y-safn	E. 13° S.	80	4 12
Maes-y-safn, East	E. (?)	79	5 4
Merllyn	E.	77–79	6 0 to 8
Mwyn-bwll	E. 12° N.	77	5 4
Pant-du	E. 30° S.	80	5 4
Pant-y-buarth	E. 8° N.	77–80	5 4
Pant-y-gôf	E. 25° N.	77–80	5 4
Pant-y-gwlanod	E. 35° S.	78	5 12
Pant-y-mwyn	E. 20° N.	81	5 12
Parry's	N.	80–82	4 8
Pen-yr-Henblâs	E.	80	4 4
Rhosesmor	E. 30° N.	75–80	10 0 to 13
Rhyd-Alyn	E.	81	7 12
South Prince Patrick ...	N.	80	5 12

Mining and Drainage.

Mining.

In the old days mining was at fairly shallow depths and the methods employed were very similar to those now in use.

In modern practice well-equipped vertical shafts are sunk and the veins cross-cut at different levels, ladder-shafts being used chiefly for access and for ventilation. Water is removed by deep-level tunnelling and by high-power pumps, the latest types being electric. Compressed-air drills and powerful explosives are employed for tunnelling, driving levels, and stoping. Ponies are used at times for underground haulage, whilst surface-haulage to rail-head is done by motor-tractors.

The mines are free from gas, except in the neighbourhood of the Coal Measures.

Prospecting is carried out chiefly by long cross-cuts, and by levels or inclines driven along any lodes cut. Horizontal or inclined diamond-drilling has not yet been taken up.

In the old days the ore was dressed by hand with flushes of water and by simple machinery, and some lump-ore found in clay is still dressed simply; the greater part, however, is now treated by machinery at well-equipped plants of which that at the Halkyn Mines (p. 133) is a fair example. In some cases the residues have been re-treated, and some may in the future be dealt with by electro-chemical processes. The flotation process has not yet been introduced.

DRAINAGE.

In the Carboniferous Limestone and Cefn-y-fedw Sandstone Series, which lie between the relatively impervious older Palaeozoic (Silurian and Ordovician) rocks below and the Coal Measure shales above, the subsoil-waters move downwards from the surface, firstly in the direction of dip; but when they reach the level of the local water-table, they commence to flow seawards under the influence of gravity, so long as the water-table is above that level. In this movement the rock-structures exert an important influence. For example: the water from an area around Halkyn moves north-eastward with a zigzag movement along joints and stratification planes. The eastward travel down dip is facilitated by the numerous east-and-west veins, and the northward travel by the cross-courses, which are usually more capacious carriers of water than the east-and-west veins.

The whole limestone area, blocked out by the veins and cross-courses, may be compared to a child's box of bricks, in which some of the faces of contact are cemented together and others left open. If such a box were given a slight oblique tilt, water poured in at an upper corner would make its way by devious routes to the lower corner. Some of the lodes and many of the cross-courses or strike-faults, either by the gangue-material, or where limestone on the west and shale on the east are brought into contact, form water-tight barriers that prevent further movement of water eastward, whereupon it travels northward until an open fault or lode is met that allows it to make a further step eastward.[1] Water can cross certain bedding-planes also in the downward direction. We may refer to this type of drainage as 'chessboard' and 'staircase' drainage.

A further consideration is that some of the lodes or cross-courses are water-tight near the surface, though not in depth, and *vice-versâ*. Again: as some of these partings are only

[1] *See* notes on water-levels on the Coetia-ball cross-course, pp. 59, 60.

partially permeable, water moves through and along them slowly and with difficulty.

The net result is that in certain areas or blocks, outlined by structural faults, the local water-table stands higher than in contiguous blocks, and is unaffected by any operations in those blocks so long as the water-tight or partially water-tight divisions are not pierced by mining operations. These considerations will be emphasized in discussing the draining of St. Winifred's Well at Holywell.

The future of lead- and zinc-mining in Flintshire and Denbighshire depends primarily upon deep drainage. High pumping-costs are detrimental and in many cases fatal to successful work, the amount of water that can be removed by pumping being only a small percentage of the amount got rid of by deep adits. The high initial costs of tunnelling, provided that the projects are fundamentally sound, are rapidly defrayed when the aim has been attained and productive lodes unwatered.

In Flintshire and Denbighshire north of the Llanelidan and Bala Faults several important drainage-schemes[1] have been mooted or promoted in recent years, as under (*see* Fig. 2, p. 24) :—

1. The Halkyn (Deep Level) Tunnel.
2. The Government (War) Drainage-Scheme.
3. The Milwr (Holywell–Halkyn) Sea-level Tunnel.
4. The Llanarmon District Mines Drainage Tunnels.

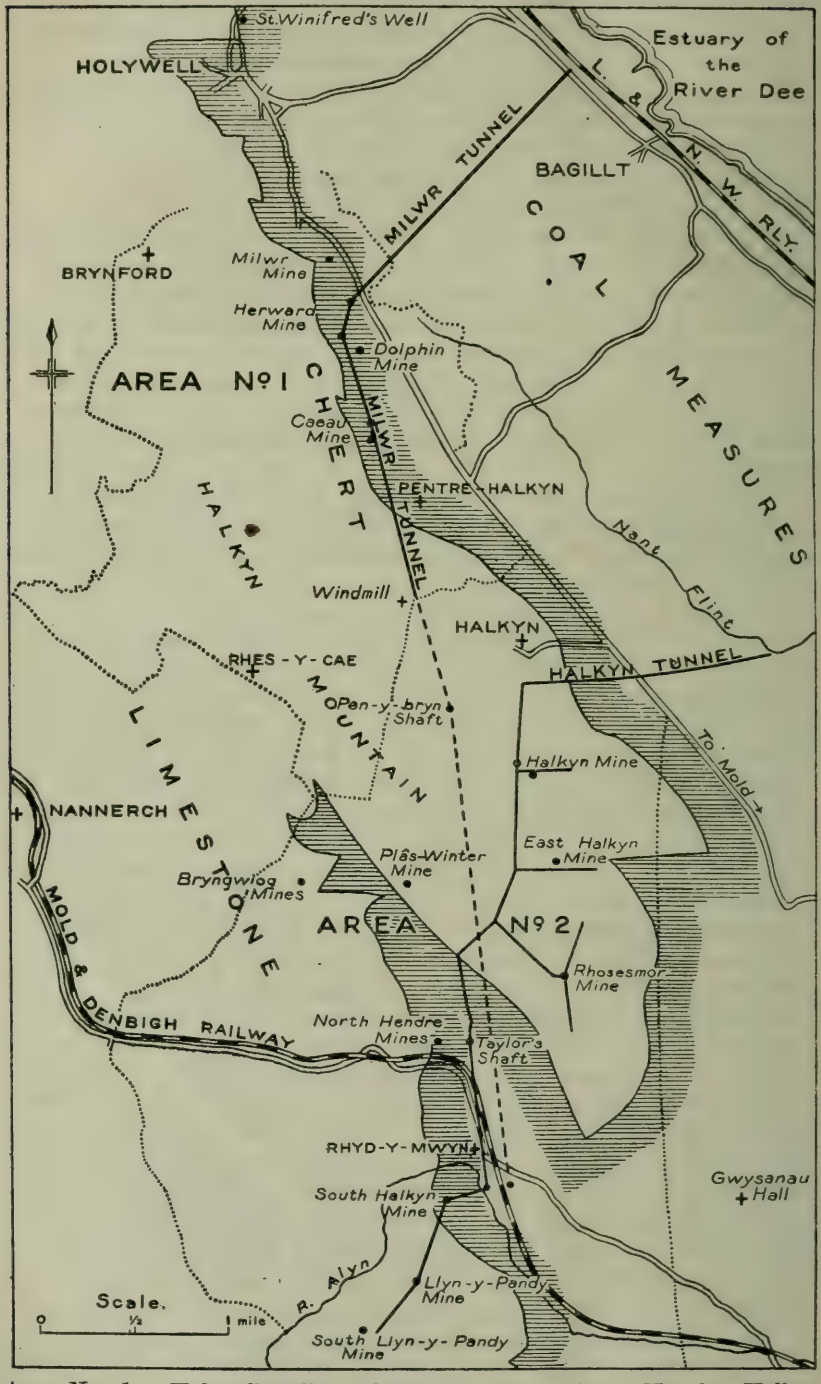
Halkyn (Deep Level) Tunnel.—This day-level, which gives its name to the Deep Level Lode, "was commenced in the "year 1818, and was driven from the stream at Bryn-moel, "near Coed-y-cra [about 150 yards below Nant Mill, Fig. 2, "p. 24], at a height of 200 feet above Ordnance Datum, running "into the Deep Level Lode near Crockford's Shaft, at a depth "of about 190 yards. In 1875 a new company, the Halkyn "District Mines Drainage Company, Ltd., was formed for the "purpose of extending the level, and an Act of Parliament "obtained giving them power to levy a rate on the various "mines benefited. By this company the level has been "extended along the Deep Level Lode and southwards in the "same line for 1,000 yards, and thence in a direction about "S. 24° W. to a point 30 yards north of the South Pant-y-gôf "Shaft, near Wern-y-Gaer."[2] From this shaft[3] the level has been continued southward to Taylor's Shaft, North Hendre Mines, and an important branch runs south-eastward to Rhosesmor Mines. From Taylor's Shaft the tunnel has been carried southward to the South Halkyn Mine (Fig. 6) and thence south-westward to the South Llyn-y-pandy Mine, where it is at the 150 yard level. Since 1875 the tunnel has been driven 4 miles.

[1] Other drainage-schemes are discussed under details of Mines.

[2] 'The Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, pp. 179, 180.

[3] 850 feet O.D.; depth 200 yards. Water-level at shaft bottom.

FIG. 2.—*Map of Drainage-Areas, Milwr and Halkyn.*



Area No. 1: Holywell-Halkyn Drainage-Area. Area No. 2: Halkyn Drainage-Area. The horizontal shading indicates the edge of the Coal Measures.

When the Drainage Company was formed the mines were practically derelict; the tunnel led to the re working of mine after mine and the discovery of new ore-bodies. In most of the lodes thus unwatered, ore has been worked out to tunnel depth, and in many cases to some distance below, by pumping. Accessible reserves are now running short and it has become necessary to face the problem of unwatering to a greater depth.

The mines unwatered wholly or in part by the Halkyn Tunnel are the following:—New North Halkyn, Halkyn, Mount Halkyn, Bryn-gwiog, East Halkyn, North Hendre and Hendre, South Halkyn and Llyn-y-pandy.

Government (War) Drainage-Scheme.—In view of the consideration that it would take a long time for the Milwr tunnel to be driven into the Halkyn Mines area (Fig. 6), and that galena and blende were both urgently required for war purposes, a scheme, subsidised to the extent of £35,000 from public funds, was set afoot to aid rapid production by pumping.[1] The scheme had almost reached fruition when the Armistice was declared, and it has now been suspended.

Under the scheme a generating-station has been built at Taylor's Shaft, North Hendre, with two pumps each capable of dealing with 2,000 gallons of water a minute, which amounts would be raised to the Halkyn (Deep Level) Tunnel. This part of the scheme could come into operation forthwith. The North Hendre Mining Co. has pumps capable of dealing with 3,000 gallons per minute, but until the mines are drained to the bottom, only 1,500 gallons per minute could be raised, some of the pumps being submerged. Powell's Mine at Rhosesmor pumps 4,000 gallons per minute.

The scheme further proposed to install two pumps, each capable of raising 1,000 gallons per minute, on the Bryn-celyn Lode at Davey's Shaft, which has been deepened for the purpose; this was expected to drain the Garreg-boeth Lode also. It was next proposed to deepen the Conqueror-of-Wales Shaft on the Llyn-y-pandy Lode and to install two 1,000 gallon pumps. The total water pumped by the combined group would then be 15,000 gallons per minute.

With a view to mitigate the water difficulty, further operations were undertaken. Certain works at Queensferry used to take water from the Halkyn Tunnel. To ensure this supply in the event of the Milwr Tunnel being driven, launders were to be installed at the Llyn-y-pandy Mine to throw a continuous supply of water into the Halkyn Tunnel. This scheme is nearly completed. The Rhosesmor branch of the tunnel also is laundered for a distance of 400 yards.

The plan at present contemplated is that if the pumping-scheme were to be set in operation at North Hendre (Taylor's

[1] *See* 'Report of the Controller of the Department of Mineral Resources of the United Kingdom,' *Min. of Munitions*, White Paper, 1918, pp. 34, 35.

Shaft) alone, two new points of attack on the Milwr Tunnel would be obtained, namely at Pen-y-bryn shaft, which would be deepened for the purpose, and at North Hendre. This would permit of simultaneous work at five different faces, and would, it is thought, reduce the time of driving from the Windmill to the Iron Shaft on the Bryn-celyn Lode, approximately from 8 to 3 years. Meanwhile the cost of pumping, capital charges, and expense of driving the tunnel should be met from the profits that would accrue from galena and blende got in the deeper parts of the lodes unwatered by pumping. The pumping-plant would be necessary, even after the tunnel is driven, to unwater lodes below tunnel-level.

Milwr (Holywell–Halkyn) Sea-level Tunnel.—This tunnel, known as the Milwr or Holywell–Halkyn tunnel, was undertaken by the Holywell-Halkyn Mining and Tunnel Co. (1896) to unwater lodes in the Holywell District (Fig. 2, p. 24), and to prospect virgin ground for new lodes. The lead-mining industry in the Holywell District had practically come to a standstill before this date. The area is covered with abandoned mine-shafts, the deepest of which had been equipped with expensive pumping-plant and machinery, which, although worked simultaneously at the various shafts, had proved incapable of dealing with the water.

Commencing in July 1897 at Dee Bank, Bagillt, on the estuary of the Dee, it was driven south-westward about $1\frac{3}{4}$ miles to the well-known Herward Mine, situated about a mile south of Holywell. Thence it deviated to the south to Caeau Mine, and has now been driven to the boundary of the Holywell–Halkyn and Halkyn Mines District drainage areas at the hamlet known as the Windmill—a total distance of $3\frac{1}{2}$ miles from tunnel-mouth. In 1908 the forebreast of the tunnel was 600 yards south of the Herward Shaft.

Some six or seven years ago it began to be recognised that the ore-deposits of the Halkyn area, drained by the Halkyn Tunnel, would soon become exhausted to water-level. The Halkyn District Mines Drainage Co. therefore secured, in 1913, another Act of Parliament to extend the Milwr Sea Level Tunnel into the Halkyn Mines Area and thus secure drainage by gravitation to a further depth of about 190 feet. The driving was advanced from the neighbourhood of the Caeau Mine southward and reached the boundary in August 1919. Since that date no further advance has been made. As above stated, it was proposed to extend the tunnel to the Iron Shaft on the Bryn-celyn Lode. A further object in view was to carry it west-of-south into the Llanarmon District.

At this stage some remarks upon the effect of driving the Milwr Tunnel upon the drainage may not be out of place. With a natural drainage of the combined chessboard and staircase type, as defined above (p. 22), it is inevitable that the driving

GEOLOGICAL SURVEY OF GREAT BRITAIN.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

VOL. XIX.—LEAD AND ZINC ORES IN THE CARBONIFEROUS ROCKS OF NORTH WALES (1921).

The following list gives, for convenience of reference, a statement of the passages in this memoir which have been reproduced, with their text figures, from two earlier memoirs of the Geological Survey, "The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn" (1885), by Sir Aubrey Strahan, and "The Geology of the Neighbourhood of Flint, Mold, and Ruthin" (1890), by Sir Aubrey Strahan. While the passages indicated have not all been reprinted verbatim, the alterations are inconsiderable; additional information has been incorporated where necessary, but as most of the mines dealt with in these sections of the memoir have long been abandoned, there is little to add to the previously published accounts.

This memoir		Rhyl memoir	
pp. 30, 31.		pp. 2–5, 14, 15.	
,,	p. 36.	,,	pp. 3, 4.
,,	pp. 38–44.	,,	pp. 46–51.
,,	pp. 49–101.	Flint memoir	pp. 163–197.

x (5)17093 Wt 29045—S 21/1206 750 3/22 E & S

secured by a combined pumping and drainage scheme, whereby it will be pumped from below sea-level at Roskell's Shaft, Holway Mine, and thrown at 230 feet O.D. into the old Holway day-level (pp. 49, 52), which also carries water from the west side of the Pant-y-nef cross-course.

The driving of the tunnel southward, by cutting several feeders from the west, may have had a minor effect in partly lowering the water-table in this area before the Pant Lode was reached, but not sufficient to lower it below the point of issue at the well. Had the lode been cut at some point other than the large cavern, it might have been possible to seal off the water

[1] *See also* Pieton Mine,' p. 59.

and maintain the head. An interesting point is that the Beili-gwyn (Milwr Mine) Lode is supposed to be crossed by the Caleb Bell cross-course westward near Holywell; yet when the Beili-gwyn Lode was cut by the tunnel, the water that issued from it could be carried by a 3-inch pipe. The Pant-y-pydew Vein also was cut, but had no effect upon the well.

The effect of the tapping of this large body of water at one point (over 4,000 gallons per minute, as against a flow of 1,160 gallons per minute at the well) upon the other mines in the district is of interest. At first no effect was felt, because the winter of 1916–17 had been wet, and no effect was felt at all in the mines extending from the New North Halkyn to the Bryn-gwiog Lode. But at Rhosesmor (p. 138), two miles south of the point of tapping the water, there has been a decrease of from 500 to 600 gallons[1] per minute on ordinary pumping, and the pumps will drain the mines deeper. At North Hendre again, still farther south, gaugings seem to show that there was some effect here also, the reduction of overflow-waters into the Halkyn Tunnel being 51·2 per cent. and 32·7 per cent.[1] at Taylor's and Hendre Shafts respectively during the following month—differences too great to be accounted for by weather conditions alone. These facts seem to make it clear that the Nant-figillt Fault, although a water-tight parting near the surface where Coal Measures are thrown against Carboniferous Limestone, must be in depth, where Limestone is faulted against Limestone, a carrier of water northward.

Llanarmon District Mines Drainage Scheme.—A Company (L. D. M. D. Co., Ltd.) was established under Act of Parliament in 1892 to unwater mines and to cut new lodes in the Llanarmon District. Although the Company is still in existence, the scheme has not been carried out.

It was proposed to drive a tunnel (No. 1) from the River Terrig, at a point about 363 feet above O.D. and about three-quarters of a mile north-east of Nerquis, westward to the Glyndwr Shaft (East Maes-y-safn). From this point a branch tunnel (No. 3) was to run north-north-west to the junction of the Gwern-y-mynydd Flat with the southern part of the Cat Hole Lode. Another branch (No. 2) was to be run from the same point to the Pant-du Lode, on the line of Waen-lâs, and was then to turn southward to the Bog Mine, which it would enter about two-thirds of a mile south-east of Erryrys. It was to have passed east of Hendre-foelas at about 250 yards depth, and beneath Graig-wolf at 287 yards depth (or 384 feet O.D.) to the Bog Mine, where it would be at a depth of 260 yards, *i.e.*, about 20 yards below the bottom of the Mary Anne Shaft (Pl. III). It was further proposed to carry the Halkyn Tunnel southward into the district at some future date.

---

[1] Figures supplied by Capt. J. Francis, Halkyn Mines.

It is now hoped that the Milwr Tunnel will eventually unwater this district.

Minera District south of the Bala Fault.—In the Minera District, drainage to a depth of about 580 feet O.D. has been secured mainly by a day-adit (p. 110). A scheme has been suggested by Mr. H. P. Harris, M.I.C.E., of the Brynmally Colliery, for driving a level (Cefnybedd Tunnel) from the River Alyn, near Gwersyllt Hall, in the Top Sulphur Coal at 208·54 feet above O.D., to unwater the coal mines as far as Vron, where it would be at about 260 feet O.D. This adit might then be extended to the Minera Mines, and would secure their drainage for about 300 feet deeper than at present.

CHAPTER II.

OLD MINES AND MINES RECENTLY ABANDONED.

Area 1.—Vale of Clwyd.

GEOLOGY.

The Carboniferous rocks of the western side of the Vale of Clwyd[1] comprise the following subdivisions :—

Coal Measures	Lower Coal Measures.
Carboniferous Limestone Series	Upper Grey Limestone.
	White Limestone.
	Lower Grey Limestone.
	Basement-Beds.

On the western side of the Vale of Clwyd the Basement-Beds attain a great development. They have been repeatedly proved in the shafts sunk in search of iron-ore along the foot of the limestone escarpment, but the best exposure occurs in Ffernant Dingle, a deep ravine about one mile south of Llysfaen, where an uninterrupted view of the lower part of the series is afforded. The upper part and junction with the limestone is seen in the farm-yard at Bryniau-cochion, where red-stained impure limestone rests conformably on green and purple shales, with rather a sharp line of demarcation. The slopes below are formed of a conglomerate of green and yellow sandstone pebbles in a red and green matrix, associated with mottled red and green shales. These are underlain southwards by a deep-red conglomerate, which in Ffernant Dingle overlies 80 feet of sandstones (chiefly red, but some green), conglomerates, impure limestones (cornstones) and red shales, resting unconformably on Wenlock Shale.

The pebbles in these conglomerates are red, green, or mottled, the green colour predominating towards the upper part of the subdivision. In colour and material the pebbles resemble the Tilestones or newest Ludlow rocks as developed in Central Wales and on the southern flanks of the Lake District mountains; they contain derived fossils of undoubtedly Silurian age, 90 per cent. of which occur in the Ludlow rocks.

The fossils are found only in the pebbles. No organic remains contemporaneous with the deposit have yet been discovered.

It is noticeable that the Wenlock Shale on which the Basement-Beds rest in all this neighbourhood, is conspicuous

[1] 'Geol. of Rhyl, Abergele, and Colwyn' (*Mem. Geol. Surv.*), 1885; 'Geol. of Flint, Mold, and Ruthin' (*ibid.*), 1890. *See also* Old Series one-inch Geological maps 79 N.W., S.W., and S.E.

by its absence in the materials of the conglomerate, except only for a few angular fragments at the base, which have obviously been detached from the immediately underlying beds.

Eastwards and southwards the Basement-Beds may be followed up the Vale of Clwyd, forming everywhere (except where cut out by faults) a narrow belt separating the Limestone from the Wenlock Shale, and, farther south, from the Ludlow rocks, which appear from beneath the Limestone Series near the head of the vale.

The Carboniferous Limestone, from near Abergele to the Dulas, forms an irregular belt of hills, about a mile in width. At Siambr-wen, south of Abergele, they are about a mile and a half from the coast, which they gradually approach in a sinuous curve until near Llandulas they are within 300 yards of it.

The limestone is of the ordinary grey and white type, but towards the base is sometimes darker, as at the southern scarp of Pen-y-corddyn-bâch At Tyddyn-uchaf, south of Gwrych, the lower beds consist of grey limestones with earthy bands interbedded.

As a rule, over this area the dip in usually north-north-west, but is sometimes due north. The angle of dip, towards the base, averages 20 degrees, whereas towards the northern side of the area it ranges from 10 degrees to 15 degrees.

A very pure white limestone has been quarried near Tan-y-goppa, and to the west of Siambr-wen. The white limestone used for Bodelwyddan Church was obtained from these beds. Towards the north, where the upper cherty beds (Upper Grey Limestone of Morton) would be expected to succeed, the series is terminated by modern sea-cliffs, or by inland cliffs, perhaps in part of the same origin, against which Glacial drift is banked up. Farther south, away from the coast, the Carboniferous Limestone Series is followed conformably by purple micaceous flaggy shales and sandstones, supposed to represent the Lower and possibly the Middle Coal Measures.

MINES AND LODES.

In the Abergele district there have been few or no developments since the time when the old lead-workings were thus described by Tiddeman[1]:—

"*Tyddyn Morgan.*—A road running up to this house passes several shafts which have apparently been made in search of metal. Hæmatite and a little galena are visible in the waste-heaps. The run of the lode is E. 30° N.

"*Ffos-y-Bleiddiaid.*—The northern end of the Castell Cawr hill has a great gash across it from top to bottom, which is

[1] 'The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn' (*Mem. Geol. Surv.*), 1885, pp. 51, 52.

named as above on the 6-inch Ordnance Map. It is evidently an old lead mine which has at some time been very extensively worked. The vein runs about E. 18° N., and has a considerable hade to the north. It has been approached by a level, to be seen in the fields to the north-east, and at the other side of the hill must have been worked under the field; for a large hole was formed in the middle of a crop of wheat, whilst I was in the district, by the falling in of the superficial deposits. Both of these veins are probably connected with the Siambr-Wen fault.

"*Cefn-yr-ogof.*—Two lead-veins cross this hill, and have been extensively worked. The northernmost has been entered from the Dulas Valley at Ty-newydd, and crosses the hill in a direction E. 20° N. towards a recess in the other side of the hill. A level has been driven to it from below the carriage-drive, and shafts are seen at intervals all the way. The other vein ranges for a much greater distance. It lies about 50 yards south of the former at the Dulas Valley end, and runs at first E. 20° S. with a hade to the south. It appears to have been a cave before it was opened out by the mining operations, and contains at its entrance beds of gravel cemented by stalagmite. The workings extend all the way to Gwrych Castle, a distance of one mile, and are well marked through the entire length. Through half its length it runs as stated, then for half the remainder of its course goes east, and for the rest comes out a little to the north-west of Gwrych Castle with a north-easterly range. An adit-level is to be seen here. In a little plantation amongst the fields, about half-way along the vein, are to be seen many small open shafts, only just about large enough to admit the body of an average-sized man.

"Three hundred yards east of Tan-yr-ogof, a mining level crosses under the road to Llandulas; it has fallen in, in the field to the north, but its entrance may be seen on the shore close to the railway. It certainly was intended to drain one or other or both of these mines, but the direction which it seems to be taking would lead it past the northerly vein to the further. I saw no evidence of any rock but limestone having been met with in it. But very little of the resulting rubbish had been left by the sea."

The following paragraph concerning these old mines, and the supposed Roman origin of the Ffôs-y-bleiddiaid, is quoted by R. Hunt[1] from the 'Records of Denbigh and its Lordship' by John Williams:

"At Abergele some Roman remains have been discovered. Here, as others have observed, are some of the most perfect Roman mines in the Kingdom. The mountain is cut across by a supposed Roman fosse, called Ffos-y-Bleiddiaid, or the Wolves' Fosse. . . . . In driving a level, towards the close of the

[1] 'British Mining,' 8vo., *Lond.*, 1884, p. 39.

last century, the miners discovered that the Romans had been deep in the bowels of the earth. They had followed the vein where it was large enough to admit a man, and where it opened into a large chamber, they had cleared it quite way. Some curious hammers and other tools were found, almost decayed to dust, with the golden hilt of a Roman sword. The level which drains those works partly supplies the town with water. . . . The mines at Cae'rgwaith, at the foot of the same hill, are comparatively modern, and were, we believe, very productive, until the water became too great for the means of drainage then applicable. . . . . Some forty years ago lead was raised in solid masses of several hundredweight each, out of a shaft about a furlong to the east of the last-named spot; but the speculators had not the means to compete with the constant influx of water. The old mines of Tyddyn-Morgan, in the same hill, were wonderfully productive a century back. . . . . Still farther west are the old mines of Cefngo'. . . . . Some thirty or forty years back, a large sum was expended in driving a level under this mountain, without meeting with anything worth the search and outlay."

Bodelwyddan Mine.—This mine (six-inch map, Flintshire 4 S.W.) is situated to the north side of Bodelwyddan Hall, in White Carboniferous Limestone, which dips northward, or slightly east of north, at from 10 degrees to 17 degrees or more, as shown by exposures in the vicinity.

Two veins[1] were worked fairly extensively, the first and more important running east-and-west and underlying north, the second nearly north-east and south-west with south-eastward underlie. The New Engine Shaft, nearly 160 feet above sea-level, is situated in the grounds about 210 yards west-north-west of the Hall, and 40 yards from the road (from Glascoed to Voryd) that forms the western boundary of the park. The Old Engine Shaft is situated west of the road, 100 yards west-south-west of the New Shaft, whilst an inclined Whimsey Shaft lies about 40 yards south of the New Shaft. A second (the East Whimsey) shaft, 60 yards deep, is 60 yards farther east.

On the east-and-west vein the highest level is the 30-yard or Adit Level. This runs for about 330 yards eastward along the lode and continues for another 530 yards in Glacial deposits, issuing about 430 yards west-south-west of the Lodge south of Ty-mawr, and from 80 to 90 feet above O.D. Other levels lie at depths of 60, 75, 90 and 115 yards. Of these, the 60- and 90-yard levels are the greater, the latter being about 440 yards in length. The 75-yard level was driven eastward from the Whimsey Shaft.

At the eastern end of the mine the lode and country-rock are truncated by a mass of 'gravel' (boulder-clay), sloping downwards at about 65 degrees and cutting out the lode 220

[1] Plans deposited at Home Office.

and 250 yards east of Whimsey Shaft at the 30- and 90-yard levels respectively. The intermediate 75-yard level was run into the gravel in an unsuccessful search for ore. It is possible that the lower parts of the vein may extend beneath the boulder-clay.

At the western end of the mine the vein appears to be cut out by a fault with downthrow west.

A second east-and-west vein is supposed to lie a short distance to the north. The only surface-indication of this is an old shaft near the Ice House, 80 yards north-north-east of the New Engine Shaft, and trial-pits in boulder-clay farther east. Beyond the western faulted boundary of the mine, an east-and-west line of old shafts, lying a little to the southward, suggests that the chief, at least, of the supposed two lodes is faulted southward in this direction.[1] No plans of these lodes have been deposited at the Home Office.

The north-east and south-west vein is less important than the main vein described above, but was worked at the 60- and 80-yard levels over a length of about 150 yards. Towards the north the lode trends northward, in which direction it appears to have been lost a little beyond the New Engine Shaft, although sought by meandering levels at 60 and 115 yards depth.

West of the Whimsey Shaft, this vein is accompanied on its eastern side by a parallel 'South Joint', which proved to be a clay-filled fissure.

The mine was worked at the 80-yard level in 1828–9, and presumably the adit was driven at this time. Old workings on the 60- and 90-yard levels were made in 1830–36. In 1854–7 the mine was again in work at the 60, 90 and 115 yard levels, the greatest quantity of ore being got at the 60-yard level on the north-east and south-west lode in 1856–7. A large amount was got at the eastern end of the mine between adit and the 115-yard level. The mine was closed in 1859 and is now waterlogged to adit-level.

Between 1851 and 1858, royalty was paid on 1,366 tons of lead-ore, sold for £19,848 16*s.* 7*d.*, and on 945 tons 10 cwts. of blende, sold for £2,886 1*s.* 4*d.* The mine had yielded ore previously to this date.

Abundant evidence of the richness of the veins in blende is furnished by the fact that rejected masses of veinstuff (large crystals of quartz and calcite, with tufaceous matter), built into a wall at Gors-isaf cottage, on the eastern boundary of the Park, are richly seamed with blende. In depth the mine is probably rich in blende, which has increased greatly in value since 1859.

As the low elevation of the surface above sea-level precludes any idea of much deeper drainage by adits, pumps would be

[1] Two veins are indicated on the Geological Map, 79 S.W.

necessary if the mine were reopened. Judging from the amount of water recently flowing through the day-level, the quantity pumped before the closure was not more than 400 gallons a minute.[1]

Across the Denbighshire border, and nearly a mile south-south-west of Bodelwyddan Hall, an east-and-west lode, on an important fault-line that displaces the base of the Carboniferous Limestone (which dips north-east at 10 to 15 degrees) was worked for some time for lead. The vein hades southward, and is crossed by a N.N.E.—S.S.W. vein, which also was productive. Of this mine, which is situated about three-quarters of a mile north-west of Plâs-newydd (six-inch Denb. 8 N.W.), but was known locally as the Coed-carreg-Dafydd Mine, no plans have been deposited at the Home Office. In 'Mineral Statistics' a mine named Plâs-newydd, which may possibly be this mine, returned an output of 145 tons of lead-ore between 1857 and 1861, about the time when the Coed-carreg-Dafydd Mine must have been last worked.

[1] Estimate by Capt. J. Francis, Halkyn.

CHAPTER III.

OLD MINES AND MINES RECENTLY ABANDONED.

Area 2.—Prestatyn to the Bala Fault.

GEOLOGY.

The Carboniferous rocks east of the Vale of Clwyd and the Clwydian Hills[1] can be grouped roughly by their lithological characters, which, however, change rapidly in a southerly direction.

The following subdivisions may be recognised :—

Lower Coal Measures	Holywell Shales.
Carboniferous Limestone Series.	Cefn-y-fedw Sandstone ('Millstone Grit') Series: cherts (N. Flint); sandstone and chert (S. Flint and Denb.).
	Black ('Aberdo') Limestone (N. Flint); Sandy Limestone Group (S. Flint and Denb.).
	Upper Grey Limestone.
	White Limestone.
	Lower Grey and Brown Limestone.
	Basement-Beds.

Basement-Beds.—These are extremely variable in thickness and character. On the east of the Vale of Clwyd they appear in the form of a red conglomerate with small pebbles (about half an inch long) in the lower part, and of flaggy red sandstone and red shales in the upper part. South-east of Dyserth the conglomerate is seen in a lane near Pentre-cwm, and near the Cwm Iron-mine. A field above Pentre-cwm is strewn with fragments of red flags, while some old shafts in the slope above have disclosed bright-red and green laminated shales. The last indication of the presence of these beds occurs at the Cwm mine, where a little laminated red shale is visible. At this point the beds are lost under Glacial drift, but there is little doubt that the Basement-Beds here thin out, leaving only isolated patches, such as those which have recently been found in the Llandegla District.[2] The thickness of this subdivision between Pentre-bâch and Pentre-cwm is about 95 feet, west of Marian-bâch not more than 50 feet, while at Marian it has thinned out, the rate of attenuation being about 1 in 55.

Lower Grey and Brown Limestone.—This consists in general of shallow-water, impure, rather thin-bedded, dark argillaceous

---

[1] 'Geol. of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890. *See also* Old Series One-inch Geological Maps 79 N.W., N.E., S.E.

[2] 'Summary of Progress' for 1910 (*Mem. Geol. Surv.*), 1911, p. 6.

limestones (occasionally bituminous); fine-grained porcellanous limestones; and rough-textured, occasionally earthy, or sandy limestones of a brownish or greyish tint. It contains beds of shale, a few thin beds of calcareous sandstone, and one or two threads of coal. Some cherts also have been found. To the east of the Clwydian Range near Llandegla this group is about 960 feet in thickness. Near Prestatyn the lower beds are extremely shaly.

White and Upper Grey Limestones.—The white limestones are massive, pure, of crystalline texture, and generally lighter in colour. They are the chief constituent of the high dissected plateau that forms the backbone of the Limestone range at an altitude of from 600 to over 1,300 feet above sea-level. The succeeding grey limestones, in the northern part of the district, are cherty and encrinital, but southward they contain beds of dark nodular and bituminous limestone and shale, of considerable importance in the Llanarmon area. The higher part of the grey limestone is rich in corals.

Black Limestone and Sandy Limestone.—In the northern part of the area, from the sea near Prestatyn by Llanasa, Trelogan, Gorsedd and Holloway, the black limestone forms a distinct upper subdivision. A faulted outlier occurs south of the Milwr Fault between Pant-Wacco and Pen-y-bryn, while farther south on Halkyn Mountain the black limestone is, in places, separated from the overlying Cherts by brown, white and blue limestones. It seems to die out near the Great Halkyn Fault north of Moel-y-gaer.

At about this point, sandstones begin to appear in the higher beds of the limestone, and increase in importance southwards. In some cases the sandstones are calcareous and may be termed sandy limestones, but in others, as near Gwern-y-mynydd, they consist almost exclusively of silica-sand, often loosely cemented, and are then indistinguishable from parts of the overlying Cefn-y-fedw Sandstone. It has been possible in some areas to map the outcrops of at least four thick beds of sandstone. There are others too small to show in this way. These alternating limestones, sandstones and shales form the 'flat-measures' of the lead-miners, since they are the chief repository for 'flats' of ore. At Gwern-y-mynydd they total 500 feet in thickness.

Faulted lenticles of limestone, usually of this higher division, occur at intervals along the line of the Bala Fault eastward as far as Hope Mountain. This mass is formed of an inlier of limestone bounded on the south by the Bala Fault, and on the west by two powerful north-and-south faults. The beds consist of grey limestones with shales and thin black limestones, with numerous beds of red and white, occasionally calcareous, sandstone. The highest bed of sandstone is a coarse white grit with quartz-pebbles.

Cefn-y-fedw Sandstone.—This subdivision was formerly regarded as Millstone Grit. The lithological changes that take place in the upper beds of the Carboniferous Limestone in passing from north to south across Flintshire and into Denbighshire are paralleled by equally-marked variation in the Cefn-y-fedw Sandstone Series. In the north the strata consist, in the upper part, of almost solid dark well-bedded chert with thin partings of shale; in the lower part, of brown and blue chert with less distinct partings. Some of the bands are bent into rather sharp folds, which do not affect the over- or underlying beds at a few feet distance. The folds would appear therefore to have been formed contemporaneously with the beds, or may be a form of current-bedding. Traced southwards, these chert-beds gradually assume the characters of sandstone, the chief and most rapid change taking place, as in the case of the highest limestone, towards the southern end of Halkyn Mountain. The beds become progressively coarser in grain southwards, so as eventually to pass into coarse and pebbly grits in the neighbourhood of Hope. For a distance of about $1\frac{1}{3}$ miles, from the Hendre Valley near Rhydymwyn, southwards, the series appears to have thinned out, and the Lower Coal Measures overlap it and rest directly upon the Limestone.[1] In this area, ore occurs uniquely in the Coal Measures. Southward the formation reappears as a pebbly quartzose sandstone, and increases to a great mass of sandstones with subordinate shales and cherts. These form the equivalent, in the south, of the Chert Beds of Flintshire.

MINES AND LODES.

1. Dyserth to Whitford.

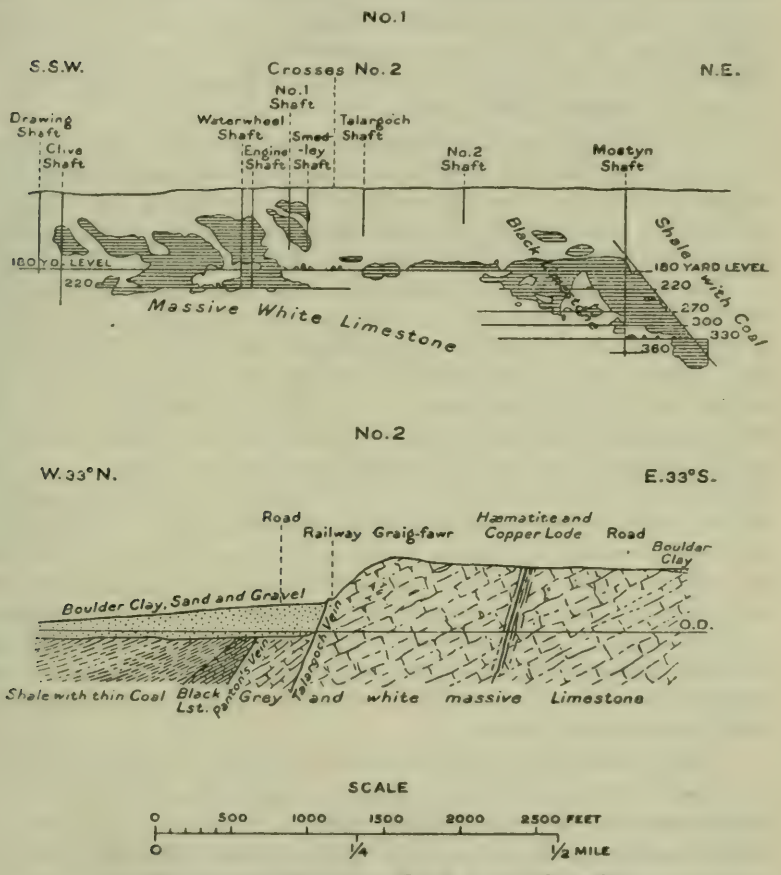
The *Talargoch Lead Mine* (Fig. 3, p. 39) is said to have been worked continuously from a very early date. It is believed that lead was mined in Flintshire during the Roman occupation, and that this was one of the mines in operation at that period. But though the strings that run down the rocky sides of Graigfawr would be among the first to attract attention, it seems hardly likely that the deep-seated veins that have yielded the bulk of the ore in modern times would have been reached through the thick water-bearing Glacial drift that covers them. In this case, as in most others, there is little more than tradition as to the date of the first workings.

In this locality the beds of limestone sweep round Graigfawr, dipping to the north and north-west until they are cut off by the great Vale of Clwyd Fault. The veins, having a general north-easterly direction, traverse the beds at an acute angle, so

[1] 'Geology of the Neighbourhoods of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, pp. 52, 53.

as to pass gradually from the massive White Limestone of the south-west end of the mine into more thinly-bedded limestone, and finally through the Black Limestone series of the north-east

FIG. 3.—*Sections of Talargoch Vein.*



No. 1, along the vein; No. 2, across the vein.

end, where they are cut off by the shales of the Lower Coal Measures; but their direction so nearly coincides with the strike of the thin-bedded limestones that the vein-products are often found occupying the position of a bed between two highly-inclined bedding-planes marked with slickenside.

The veins are three in number, and are known as Panton's Vein on the north-west, the Talargoch Vein in the centre, and the Cae-llys, Coetia-llys, or South Joint to the south-east. They are roughly parallel, and all hade or underlie to the north-west. The direction and hade of the Talargoch Vein at various points are as follows:—at the south-west end, N. 22° E., at 1 in 2; under the high-road, N. 34° E.; near the office, N. 50° E., at 1 in 7; near the Methodist Chapel and at the Mostyn Shaft,

N. 50° E., at 1 in 2; and at the north-east end, N. 50° E., at 1 in 5. The direction of the South Joint varies from about E. 8° N. in its southern part to E. 41° N. towards the north, the hade being about 1 in 3. It has been worked for a distance of about 200 yards southwards from the shale-fault that forms the northern boundary of the mine. Panton's Vein first appears a few yards north of Walker's Shaft, and runs N. 30° E., curving to N. 50° E. on approaching the shale-fault. The Talargoch Vein alone runs the whole length of the mine, a distance of about 1,400 yards.

In former days a large quantity of gravel-ore[1] was obtained from the base of the Drift. It was found in large water-worn lumps distributed over the surface of the rock, and was obtained by driving galleries in various directions through the gravel, which had been drained of water by the pumping in the mine.

The workings in the Talargoch Vein have been carried to a depth of about 400 yards from the surface at the north end, and in the South Joint and Panton's Veins[2] to about half this depth (*i.e.*, a little below the 180-yard level; a small patch was also worked at the 220-yard level). In 1881 a lode rich in blende, but with little lead, was being worked at the former depth in the Talargoch Vein, while to the south, pockets and flats connected with the same vein, at 220 yards depth, were yielding large quantities of lead with little or no blende. The replacement of the lead by blende in the depth proved unfortunate for the mine. The shallower parts of the veins mentioned above may be considered exhausted. As shown in the accompanying section (Fig. 3, No. 1, p. 39) the White Limestone of the south end yielded vast quantities of ore, while the Black Limestone also was highly productive, though in other mines it has generally been found to be barren.

At the south end of the mine the Talargoch Vein splits up into and is intersected by numerous small strings from which a great quantity of ore has been raised. Some of them may be seen running up the sides of Graig-fawr and the rock on which Dyserth Castle stands. Their direction varies from E. 25° N. to about E. 50° N.; but one of the strongest, known as the China Rake, runs E. 10° S., intersecting and cutting off the others. It obtains its name from the fact of its being filled with a fine silicious vein-stuff, which has been used in the Staffordshire Potteries. The deposit in its unweathered state resembles granular quartz, but readily weathers into a loose pure white sand (p. 12). It often contains lumps of calc-spar and galena, and is clearly a chemically formed vein-product, not to be confounded with the chert-breccia found in the veins at the north end of the mine. Silicious vein-stuff is commonly

[1] Masses are said to have been found so large as to have yielded 80 tons of ore.

[2] Plans and sections of the mine are deposited at the Home Office.

found in the Flintshire veins, especially in the beds that lie next below the Chert, but not often in such purity. From the China Rake the silica runs down towards the Clive Shaft along a string from which it has occasionally been raised.

In some of these strings, calamine, locally known as 'coke,'[1] was formerly worked, and one of the day-levels in Graig-fawr was called the Coke Hole. This mineral used to be abundant near Holywell, where it has been worked since the year 1740. It was found in the shallow parts of the veins only.

The total production of galena from the Talargoch Mine in the years 1845–84 inclusive amounted to 57,752 tons, yielding 43,821 tons of metallic lead (or about 75·8 per cent.), and an average of 9½ ounces of silver to the ton. The yield of blende in the years 1855–84 inclusive was 49,810 tons. The average yearly sale for the three years 1880–82 was stated in the advertisements offering the mine for sale in the year 1883 to be 1,035 tons of lead and 3,041 tons of blende. But in the year 1883, though 2,910 tons of blende were raised, the production of lead fell to 391 tons, and in May 1884 the pumping was abandoned, and the mine allowed to fill with water up to the day-level. Subsequently operations were confined to the re-dressing of the old rubbish-heaps, which in the period from 1885 to 1898 inclusive yielded 346 tons of galena and 2,330 tons of blende, whilst a further 116 tons of blende were extracted in 1904–1905.

Among the smaller mines may be mentioned the *Golden Grove*, situated in a valley running past the house of that name towards Llanasa. It is said that a broad vein of spar ranging down the valley and hading to the north was struck, with a direction apparently of about E. 10°–15° N. The limestone exposed in the sides of the valley is dark, and thin-bedded with chert-bands, and is probably on the same horizon as that of Carreg-y-frân.

Near the Volcnant Telegraph Station a joint ranging nearly east-and-west through the Chert has been worked. It is stated that this joint is a continuation of the Talacre Vein, but there is no evidence to confirm this view. A number of small shafts were sunk, and an adit-level was driven in the underlying Black Limestone from the edge of the marsh near Terfyn to a dingle on the west side of the Gwaenysgor road.

Farther to the west, along the same line, a shaft known as the *Nant-y-mwyn Mine* was sunk to a considerable depth in the Black Limestone, but no lode was discovered. The adit-level was driven under Nant Mill from near the site of Prestatyn Castle.

[1] There is some uncertainty as to the origin and spelling of this name. It may be derived from the friable and cinder-like appearance of the mineral. It must not be confounded with 'cawk,' a popular name for barytes.

A shaft was commenced in the Glacial drift on the north side of the road from Prestatyn to Gwaenysgor, but abandoned before reaching rock. On Carreg-y-frân, a joint, running about E. 20° S., has been opened, and about 1890 still showed traces of galena on the walls. With the intention of catching the intersection of this joint with veins supposed to range in this direction from Talargoch, a shaft was commenced in the year 1877 near the foot of the hill, but after traversing 204 feet of Glacial drift was abandoned without reaching rock. From what is known of the effect of the great Prestatyn Fault, it may be gathered that it is not likely that a metalliferous rock would be met with in the low ground.

Farther south (west of Gwaenysgor), levels have been driven into the hill-side along joints ranging about east and east-north-east, but without resulting in any discovery.

The workings of the *Dyserth Mine* were carried to a depth of 40 yards in a vein that appears to have ranged N. 23° E. In the 'Mineral Statistics' for 1869 a return of 16 tons of galena was made for this mine, and the ore is stated to have yielded 12 ounces of silver per ton of lead—a high proportion for this district. A deposit of iron pyrites in a stalactitic form was met with in the western workings. Two veins, on one of which small trials have been made, may be traced over Cerrig-Heilyn in a north-easterly direction; the southernmost is filled with a deposit of chert.

The Ash-tree Shaft on the south side of the waterfall was opened on a vein running a little east of north; the western workings encountered the Coal Measure shale.

In the *Talacre Mine* two metalliferous veins, known as the Talacre or Spar Vein and the Joint-y-clawdd, respectively, run through the top beds of the Chert at Gronant. The Talacre Vein is a fault with a small downthrow to the south, and underlying therefore in this direction. Up to about 1884 it had been worked principally at the eastern end, near the fault that throws the Chert against Lower Coal Measures. Westward it had been followed as far as the Sycamore Shaft, near the Calvinistic Methodist Chapel, and is believed to run through some old surface-workings by the side of the road leading to Golden Grove. The direction of the vein at the eastern end is a little south of east, curving by the Engine Shaft to E. 10° N., and near these old workings to about E. 20° N. The Joint-y-clawdd is a vertical string running through the Pentre chert-quarry, which intersects the old workings, and thence along the edge of the plantation, passing 90 yards south of the Engine Shaft to the smithy, near which it is said to join the Talacre Vein. The old trenches along the joint were formerly open for about 250 yards, and provided the reason for the name (clawdd, ditch); they show the junction of the Chert with the overlying shales. The general direction of the Joint-y-clawdd is E. 20° N. A similar joint in the same beds, and bearing

N. 40° E., has been worked open-cast by the side of the road near Kelston Farm. This is probably the Marian Lode.

Towards the western end of Talacre Mine, south of Gronant, there appears to have been more than one lode worked on more or less parallel lines. The Shaft-y-maes was drained by a day-adit issuing a few feet above sea-level at the high-road north of Gronant Mill. From this shaft, workings on the California Vein (28-yard level) and Ffynnon-Fair Vein (48-yard level) were reached a few yards to the east. These workings were clustered about Shaft-newydd, 7 chains to the east of Shaft-y-maes. The veins were nearly parallel to and north of the Clawdd Vein.

The workings on these veins are all in the Chert Beds, which are of great thickness, the lowest level on the Talacre Vein being at 105 yards depth. At the time of Mr. Strahan's survey the mine was inactive, and the following description is taken from a paper by M. L. Moissenet.[1] The hade of the veins was 2 in 3 at the top, and 1 in 1 lower down. In the 30-yard level from the Engine Shaft going west, the lode was at first almost barren in a dull chert, but after joining another equally poor it acquired a width of 6 yards, and contained a mass of galena 6 feet thick. West of this junction the vein spread into three or four strings, the northern one showing chert in the hanging, shale in the hading, side. In the 48-yard level the vein was several yards broad, with chert in the hanging and 'gravel' in the hading; a cross-cut to the Engine Shaft ran for 30 yards in the sand. Round ore (gravel-ore) occurred in the gravel at the contact of the rock. The mine yielded galena, calamine, and a little 'white lead,' but no blende. The galena contained more silver in the western than in the eastern part of the mine.

Buckland[2] also refers to this mine (as the Gronant Mine).

The 'gravel' referred to by M. Moissenet appears to have been a Glacial gravel, such as that described at Talargoch. The sand was probably a disintegrated silicious vein-stuff, similar to that which filled the China Rake (p. 40). Parts of it were of a pure white, and so fine as to be impalpable; it contained lumps that generally crumbled down when rubbed in the hand, but sometimes enclosed cores of light-blue chert, the form in which probably the material was originally deposited in the vein. In other parts the vein-stuff consisted of a chert-breccia in a cement of white calc-spar with blende. Specimens of the various vein-products, of black and light-coloured banded chert, of light-yellow and brown cherty sandstones with an occasional fragment of encrinital chert, and of black silicious shales, were all to be seen in abundance in the pit-debris.

---

[1] 'Mémoire sur le Gisement du Minerai de plomb. dans le Calcaire Carbonifère du Flintshire.' *Annales des Mines*, ser. 5, tom. xi, 1857, p. 351.

[2] 'Reliquiæ Diluvianæ,' ed. 2, 1824, p. 178.

Up to the close of 1861 more lead than zinc ore had been raised at Talacre; but subsequently, in the years 1870–84, during which the mine was in operation, the zinc-ores were in preponderance, the tendency of the blende to replace the galena in the deeper parts being even more marked here than at Talargoch. The amount of lead-ore raised from 1849 to 1882 reached a total of 3,564 tons 5 cwt., with a yield of silver varying from $8\frac{3}{4}$ to $9\frac{1}{2}$ ounces per ton of lead. The total yield of zinc-ores up to 1884 was 5,517 tons 2 cwt., the returns in 1883 and 1884 being 645 and 720 tons.[1]

Since the date of the six-inch geological survey of this area (about 1884) a considerable amount of work has been done in the Talacre Mine. It remained continuously in work until, after one year's interval, it was taken over by the Talacre District Mining and Drainage Co. in 1892 and worked until June 1907. During the period 1885–1907 inclusive, 138·5 tons of galena averaging 81·5 per cent. of lead, and 12,597 tons of zinc-ore with from 40 to 60 per cent. of zinc, were obtained.

The Sawney Shaft, situated about 200 yards west-south-west of the stables at Talacre Hall, is entirely in cherts, and was sunk vertically for 156 yards on the site of an old ladder-shaft that went down only to the 105-yard level. The shaft cut through the vein. An 80-inch Cornish engine was bought but not utilised, because the blende found at the bottom of the mine proved to be so poor that it did not pay to work, although a considerable quantity of the mineral, as well as a little galena, was got between the 120- and 156-yard levels.

The chief work done by the company consisted in extending the day-adit, which had previously been driven to the mine from the north. Three small shafts had been sunk on this adit, which embouches near a sharp bend in the high-road about 860 yards east of the Shaft-y-maes adit-mouth.

From the Sawney Shaft the day-adit was driven in a general south-eastward and south-south-eastward direction for a total distance of 980 yards, and several lodes were intersected. The Clawdd Lode was found just south of the shaft. A new lode (No. 1) was cut at a distance of 58 yards, and in 1901–3 a driving was made eastward upon it for 125 yards, and a rise put up, galena, 1 ton to the fathom, being met with in bunches. The lode was followed westward also for $81\frac{1}{2}$ yards, satisfactory indications being observed at this end.

Two lodes of little importance (Nos. 2 and 3) were cut farther south, before the Marian Lode, referred to above, was reached. The latter was cut in 1898 at a depth of 120 yards in chert, 460 yards south of No. 1 lode, and was found to be split up into several branches hading generally northward. There were indications of ore in the shape of decomposed limestone and chert and gossan. A rise was put up on the vein and the old

[1] 'Mineral Statistics of the United Kingdom.'

surface-workings reached. A driving on the lode westward for about 30 yards passed into a dark limestone, with from 2 to 3 feet of calc-spar but no blende, though blende and a little galena were got in the cherts.

A small cross-cut was made southward in the line of the tunnel, and a driving was carried eastward in the lode to find bearing-measures beneath the shales that overlie the Cherts in this direction, but a steep wall of shale was met and chalybeate water struck. The wall of shale is some distance west of the large Axton Fault, which throws down the overlying shales and sandstones of Gwespyr (Lower Coal Measures) on the east, and may represent either the shale turned over steeply, or a minor fault parallel to the major one.

The adit-level cross-cut was continued southward from this point, following the slightly sinuous chert-and-shale boundary, said to be nearly vertical.

Just before May 1901 the Kelsterton or Kelston Lode was cut at the end of the adit, 160 yards south of Kelston Farm. A short driving was made westward and a 15-inch seam of spar found, together with a large flow of water. In 1902 a 65-yard rise was put up and heavy water encountered. The lode improved upwards, and patches of blende with occasional spots of galena were found; the surface of the ground is 75 yards above the top of the rise. No further work was done owing to lack of funds.

An old lead-shaft in a wood about 300 yards south-west of this spot is probably on the same lode.

The Axton vein, worked from the old *Axton Mine*, lies about half a mile south of Llanasa, on the western side of the Axton Fault, at a point where the fault throws the top of the White Limestone and the base of the black 'Aberdo' Limestone on the west against the lower part of the Holywell Shales, with coal, on the east.

The vein itself occurs in, and parallel to the strike of, the White Productid Limestone (beneath the 'Aberdo'), in which the dip is a little west of north at about 35 degrees, decreasing, however, to about 17 degrees close to the fault. The vein trends a few degrees south of west for nearly three-quarters of a mile, but along the middle part of its course it bellies northward over a distance of about a quarter of a mile in accordance with a change in the strike of the limestone. Near the fault the vein hades northward at 33 degrees from the vertical, and has been worked down to the 66- and 95-yard levels. The western part of the vein is said to run beneath three old shafts situated from 150 to 260 yards south-west of Tyddyn-uchaf.

On the south side a nearly parallel joint, 44 to 60 yards away, was found by a cross-cut made 330 yards west of the Axton Fault. It was traced for 200 or 300 yards in a westward direction.

The old lead-works and one of the shafts are situated almost on the line of the Axton Fault, just north of the 95-yard level.

Other shafts occur farther south, the most distant being about 240 yards south of that mentioned above and a few yards west of the fault. From this a cross-cut was made for 50 yards north-westward, to a short level trending north-east, possibly on a small joint. The cross-cut also appears to have proved the fault to the eastward. The best lead-ore raised at the old Axton Mine was got in 1851.

West Trelogan Mine is a small venture situated east of the Axton Fault and about 300 yards south-east of the Axton Mine shaft, or 8 chains north-north-west of the crossing of the Llanasa and Trelogan roads. At this point the Axton Fault throws the Cherts on the east, with fairly steep northward dip, against Carboniferous Limestone on the west. The Cherts are succeeded northward by the Lower Coal Measures, proved in a shallow shaft on the north side of the road about half-way between the Axton Mine shaft and West Trelogan shafts.

The two West Trelogan shafts lie fairly close together, No. 1 west of the road, No. 2 east of the road; they were sunk to work an east-and-west vein that hades southward. No. 2 shaft had fallen in, but has recently been reopened and renamed as No. 1 by a new company. This shaft is 60 yards deep, with levels at 23½, 36, 45 and 60 yards respectively; its bottom is about 200 feet higher than the water-level in the Trelogan Mine adit. The old No. 1 shaft, sunk almost on the outcrop of the vein, is 25 yards deep.

Recently ore was got from a 6-inch metal-vein or stringer, which branches off from the south side of the main lode and trends east-south-eastward. Above the 60-yard level the main lode is of a kindly nature and about 3 feet in width, with a bunch of ore here and there.

About 64 tons of lead-ore were raised between 1911 and 1916, averaging from 62 to 78 per cent. of lead. At an earlier period the mine had been worked for several years before 1896.

The *Trelogan Mines* lie farther east, beyond a north-and-south fault (through Afon-gôch) that throws down eastward, and shifts the Chert outcrop southward for about 200 yards.

The main Trelogan Vein trends generally north-eastward. Commencing in the south at the east-and-west Pen-y-ffrith Vein, in 'Aberdo' Limestone, it extends for half-a-mile to beyond Perth-y-maen, cutting the overlying Cherts and Coal Measure shales. The latter crop out beneath Glacial deposits about 320 yards north of the Pen-y-ffrith Vein.

The main vein, which was prolific in the Limestone and Cherts only, hades westward, and has been worked from several shafts. The southernmost was sunk on the junction of the Trelogan and Pen-y-ffrith veins. The West Whimsey Shaft, 100 yards north-west of the White Horse, is 115 yards deep, and passing through Coal Measures and Chert, nearly reaches the Limestone. Roft Shaft, 340 yards farther north-east, is sunk to the 132-yard level, but here the workings in the Chert extend

still lower. Between West Whimsey and Roft are Smithy and Qually Shafts. The most northerly shaft is Hannah's, 210 yards deep, which lies 260 yards north-east of Roft Shaft. The depth to the Chert at this point is 140 yards, and the inclination of the vein is about 73 degrees from the horizontal.

The higher (*i.e.*, southern) parts of the vein are unwatered by a day-level driven before the year 1783 to unwater the Afon-gôch Vein referred to below. Leaving the Trelogan Mine, in which it forms the 80-yard level, near Hannah's Shaft, the level embouches on the Afon-y-garth valley about 650 yards east-south-east of Bryn.

North of West Whimsey Shaft the Trelogan Vein is accompanied on its western side by several ore-bearing veins or strings, namely, the Holland, White and Holyoak strings, more or less in one line, and the North or Langworthy string, lying westward of Holyoak string near Hannah's Shaft. Farther south the White Horse Lode, trending a few degrees east of north, crops out in the Cherts about 100 yards south-east of the White Horse Inn, and plunges beneath the Coal Measures. Its trend is indicated by several aligned shafts.

The east-and-west Pen-y-ffrith Lode in the Aberdo Limestone, referred to above, hades northward; it is drained by the 80-yard adit-level.

The Afon-gôch Vein, which trends west-and-east and apparently hades northward, lies from 60 to 70 yards north of the road to Axton, outcropping in Cherts and terminating westward against the above-mentioned north-and-south Afon-gôch Fault. Whether it is mineralized eastward as far as the Trelogan Vein is doubtful. It was drained apparently by the day-adit, and its course is marked by five or more shafts.

The most recent plans of Trelogan Mine, deposited at the Home Office, will not be available for reference until the middle of 1921.

The earliest published returns from Trelogan Mine are for 1848, when 15 tons of lead-ore were got. There is then a gap until 1859. From that year to 1873 the mine yielded about 2,594 tons of lead-ore, with about 6 ounces of silver per ton, and 7,542 tons of zinc-ore. After this date a little ore was got at intervals from the waste-heaps, and the mine was in active work from 1898 to 1909, during which period 2,400 tons of galena were got, averaging 81·33 per cent. of lead and yielding about 9 ounces of silver per ton, and 15,346 tons of zinc-ore, averaging about 52 per cent. of zinc.

Several ore-bearing veins lie to the south-east of the Trelogan group, on the west side of an important fault trending west of north, of a similar type, and parallel to the Axton Fault mentioned above (p. 45). This fault, which we may refer to as the Garreg Fault (or Spar Vein), since it passes east of Garreg, has a large downthrow eastward, throwing Lower Coal Measures (Gwespyr Sandstone) on the east against the Carboniferous

Limestone on the west. Near Hafod, which lies about 450 yards south-west of Pentre-ffynnon, are the Butcher and Bryn Veins, both hading northward and occurring in the higher beds of the White Limestone, a little south of the outcrop of the overlying Black (Aberdo) Limestone. The Butcher Vein trends approximately W. 27° N., and is nearly half a mile in length, but has not been traced up to the Garreg Fault. Crockford's Shaft is 44 yards north-west of Hafod, a few yards south of the outcrop of the vein.

The Bryn Vein trends about W. 15° N. for about 3 furlongs and meets the Garreg Fault. The Old Engine Shaft is on the outcrop of the vein, 140 yards south-west of Hafod, and the vein was lost about 70 yards west of this point, although the adit was carried some distance farther. A considerable quantity of gravel-ore was got in the area east and south-east of Hafod. Lodge Shaft (over 600 feet O.D.) was situated about 66 yards west of the Garreg Fault; at this point the adit-level leaves the vein and embouches about 350 yards to the north-east at 423·5 feet O.D. The Garreg Fault in this neighbourhood is a spar-vein in which bellies of ore were found.

Some distance farther south is the Pant-yr-hwch Vein, about 150 yards north of Pant-yr-hwch, trending slightly north of west and hading northward. It is over half a mile in length and touches the Garreg Fault, near which point gravel-ore also was got. One or two old shafts (629·1 feet O.D.), in limestone, lie on its south side about 280 yards east-north-east of Pant-yr-hwch. This vein was probably drained by an adit-level driven first southward from Plâs-uchaf, east of the Garreg Fault, and then westward.

About 300 yards farther south, on the north side of Garreg Mountain, are two short veins close together; the northern or Garreg Vein hades north and was worked from a fairly deep shaft; the southern, which hades south, was worked from a shaft 120 yards deep, the adit-level being at 80 yards. The Limestone here dips north-eastward. The latest date of lead-ore being obtained at *Garreg Mine* was 1864.

A little over a mile westward is the old *Glol Mine*, half a mile west of the farm of that name. It was on a small strike-vein trending E. 10° S., and was worked from three shafts close together.

Pant-y-garreg or *Tan-yr-onen Mine* lies a few hundred yards north-east of the hamlet of Garreg, on the Garreg Fault, which is mineralised at this point and southward for a long distance and is known as the Spar Vein. It was drained by an adit at 60 yards, emptying north-eastward into the stream that flows past Whitford. Several old shafts lie on the course of the lode, which throws off the Personoliaeth Vein in a south-easterly direction about 250 yards south of the mine. Lady Harriet Shaft, 270 yards south-west of Terfyn-dwydre, is the most easterly of the shafts on this latter vein. Thereafter the main

fault, which goes by the name of the Vein-uchaf, continues southward as a cross-course, heaving the Merllyn Vein in its passage, and proceeds southward as the Pant-Wacco Fault (p. 55), which bounds the western side of the Calcoed outlier of Lower Coal Measures introduced into the middle of the Limestone-area by the united influence of three large faults.[1]

The Coetia-dwr Vein, a downthrow to the north-east, worked from the St. David's and other shafts, springs off the Vein-uchaf at a point about 170 yards south-west of Ty'n-twll, and trends south-eastward in the highest beds of the White Limestone. Argentiferous galena was raised here, but the mine was drowned out about 1844.

The Vein-uchaf, north of the Merllyn Vein, is marked by several shafts. On its western side is the short Trymaen Vein, trending north-west and underlying north-east; on its eastern side is the Trymaen-isaf Vein, trending about N. 17° W. and underlying east, with the Bryn-forwd Shaft; it contained some copper pyrites.

The Merllyn and associated veins are described in the next section, pp. 55, 56.

2. Whitford to Holywell and Halkyn.

The Old Holloway and adjoining Veins.—The principal vein worked in the old *Holloway* or *Holway Mine* forms the northernmost of the long series of lead-veins of Halkyn Mountain. It runs nearly due east-and-west, curving slightly southwards towards its eastern end at Holywell. It has been worked from near Holywell continuously to Pant, where it is broken across and shifted by the Pantasa Fault, and from Pant to Pant-Wacco, where again it is temporarily lost in faulted ground. It seems to reappear west of Pant-Wacco in a vein known as the Boutflour, and is believed to run on through Coed-Pen-y-gelli past Ffyddion; the total distance proved (including the Boutflour Vein) being nearly $2\frac{3}{4}$ miles. The vein throws the strata down to the north, and forms a conspicuous feature, especially towards Holloway, where it brings Lower Coal Measure shales in its north or hanging side against the Limestone and Chert Beds of Coed-saith-aelwyd, which form its southern side or foot-wall.

The vein is drained by a level (pp. 27, 51) that opens into the Holywell valley about 100 yards north-west of St. Winifred's Well, at a height of about 230 feet above the sea. The level was used for many years as a canal for the conveyance of ore from the mine in barges, and is still known as the boat-level. Pennant describes it as follows:—

"The Holywell level was begun in 1774 . . . I and my two sons made the voyage of this important venture on

[1] 'The Geology of the Neighbourhoods of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, pp. 61–4.

September 21st, 1795, and took boat, or rather punt, at the entrance into the work in Coed Cae Dentir. . . . We entered the mouth lighted by candles, stuck in each side of our vessel. The first 40 yards of our way was arched with stone, and so low as to oblige us to stoop. When the arch ceased, the roof was the natural rock, of that species called *shale*. The height begins now to be six feet; the breadth four; the depth of the water, included in the height, is two and a half. After passing in the shaley stratum about 226 yards, we find it is succeeded by that of *chert*, at which spot the level enters my ground, in the field called Coed Cae porfa. There the height to the surface is 18 yards. Several shafts have been sunk for air between this place and the mouth of the level. In a field of mine, called Cadlas hîr, was early discovered, at the depth of 31 yards, a strong string of ore, which raised the hopes of the adventurers in the highest degree; and the mineral stock rose in proportion. But alas! in a little time, both spirits and stock fell; for the promising prospect suddenly vanished, an accident too frequent with miners to occasion surprise. The Chert continues to a little beyond the turn-pike road, when we again enter the land of Sir Pyers Mostyn, in a field called Brocknallt, where it stops. Hitherto the level has preserved a strait course: but in this field (where the limestone stratum begins and is continued to the end of the present workings, above 500 yards) it takes a bend parallel to the road, and so continues so far as Brocknallt-pella, and then makes another curvature, and near a small but pretty cave crosses obliquely the turn-pike road. . . . Out of this cave is a passage, or sump, or short shaft, sunk for the purpose of both searching for ore, and also for conveying of air, which began to be wanted, into the level. This sump communicates with several others, till it reaches a shaft. . . . In proceeding further we were alarmed with the awful sound of a cataract. On arriving at the spot from whence it issued, the noise seemed to have derived its greatest force from the confined arch of the level; for we discovered it to proceed from a small but elegant cascade, which, in our sight, tumbled down a small hollow, and served to augment the water of the level, which was also increased by several strong springs rising from the sides and bottom with strong ebullitions. Similar noises are said to have been heard in Caetiau'r Odyn. It is possible that this subterraneous water may be one of the feeds of St. Winefride's Well, as the field is nearly in a descending line with it. I have also heard, on good authority, of another large stream of water running through a great subterraneous cavern, in working Portaway mine, in Pantasa, in the parish of Whiteford, but its discharge has never been discovered. But to return. After passing this fall, we reached the end of our voyage, at the length of 1,167 yards from the mouth, and at the place where two miners were pursuing the working of the level, and had

got within ten yards of the shaft in which the miners are working in the rich vein, beneath the field called Coed Cae Plwm, or the wood or field of lead. The height from the sole of the level to the surface of this place is ninety-three yards and a half."[1]

The shaft alluded to is the Old Whimsey Shaft, 260 yards east of Holloway House. In 1879 the level ended at a point in the vein 500 yards west of this shaft, or at a total distance of 1,667 yards from the mouth. The Holloway Vein bifurcates at Bron-Holloway, the northern branch or Brammock's Vein running due east, towards the mouth of the boat-level, while the southern branch, or the Old Holloway Vein, ranges rather south of east, towards the row of houses called Brocnallt. The easternmost shaft on the Old Holloway Vein is the Garden Shaft, which lies on the north side of the high-road 220 yards west of Brocnallt. The level was driven to intersect the Old Vein, and reaches it a few yards west of the Garden Shaft, a branch being driven northwards to Brammock's Shaft to drain Brammock's Vein. From near the same point a branch-adit was driven south-eastwards towards the Halfway House to unwater some north-and-south cross-courses. From the Garden Shaft the level runs in the vein to the point named above west of Holloway House, sending off a branch to the north from the Old Whimsey Shaft to Eyton's Shaft.

The western workings on the Old Holloway Vein are drained by the Gorsedd level, which, starting at Tre-Eden-Owen, at a height of about 400 feet above the sea, runs under the road at the Merllyn and Gorsedd Mine, near Waen, to the Coetia-eithin shaft, 160 yards north-east of the Druid Inn. Thence it runs in the Old Holloway Vein eastwards to near Pant, and westwards for an unknown distance.

The Old Holloway Vein and Brammock's Vein in their course eastwards pass obliquely from the outcrop of the Chert under that of the Lower Coal Measures, and the working in them has been stopped only by the increasing depth to the Chert and Limestone below in that direction. Brammock's Vein is reported to have proved very rich; it is a double vein, the two parts being 17 yards apart, but getting closer together downwards. Roskell's Shaft, which was sunk with the expectation of catching the two as one vein at a depth of 150 yards, penetrated bastard chert and shale to a depth of 80 yards, but was then abandoned in favour of the Partridge Shaft on the newly discovered Partridge Vein.

Roskell's Shaft was sunk by the Great Holway Mining Co. (*circa* 1877), and subsequently the mine was kept in work under this title by Capt. Hotchkiss up to about 1887. During this period the shaft was deepened to the 100-yard level, and

[1] 'The History of the Parishes of Whiteford and Holywell,' 4to., *Lond.*, 1796, p. 249.

3,546 tons of lead-ore raised, and still more of blende. The shaft-section is now as follows:—boulder-clay, sand and gravel, 15 yards; shale, 45 yards; chert, 50 yards. The bottom of the shaft is in disturbed ground, supposed to be the division between the Chert and the Limestone.

Brammock's Vein was worked by the company between the 60- and 80-yard levels from the Little (Level) Engine Shaft to Roskell's Shaft, galena and some blende being raised. Capt. Hotchkiss worked the 80-yard level in Roskell's Shaft westward to Victoria Shaft.

The mine was then abandoned for two years, after which Capt. Hotchkiss re-opened it as the *Hotchkiss Mine*. The Vieille Montagne Co. came into possession about 1901 and worked Brammock's Vein for three years, after which Capt. Hotchkiss again took it over for two years or so, up to about 1905–6. During these latter stages all the workings were above water-level, which stood at 12 to 13 feet below the adit-level, and more blende than galena was got.

At some period before 1887 it was proposed to drive the 80-yard level in Roskell's and Little (Level) Engine Shafts westward to the Pant-y-nef cross-course on No. 4 Lode (? Partridge Lode), but this driving was not carried out. At 95 yards depth a cross-cut, 80 yards long, was driven northward from Roskell's Shaft into Coal Measure shales.

Pumps have been installed recently (1919) at Roskell's Shaft to raise water from the Maes-Whitford cross-course (which crosses the Old Holloway Vein at this point) to adit-level, in order to supply Holywell town, the Holy Well, and the Greenfield Mills. The adit also carries water impounded on the west side of the Pant-y-nef cross-course 1,667 yards from the adit mouth (pp. 27, 60).

Near the Old Whimsey Shaft a double vein branches out from the Old Holloway Vein towards the north-east, known in its two parts as the Old Whimsey Vein and the Miller's Vein. At Holloway House a branch having nearly the same direction leaves the main road and runs under Holloway Farm under the name of the Partridge Vein, but splits up into strings after passing the Pant-y-nef cross-course.

This cross-course forms the strongest of several that run down from Pen-y-ball northwards, and its old shaft-hillocks form conspicuous objects as seen from Holywell or Greenfield. Taken in order from east to west, they are named as follows. The Coetia'r-odyn ranges from Yr-odyn to the Halfway House, south of which it joins the Maes-Whitford, and runs on to near Brynford, under the name of Sir Edward Lode; it points for the mouth of the boat-level, the Maes-Whitford ranging towards Roskell's Shaft and carrying no blende. The True Blue cross-course ranges from near Pen-y-ball Farm to the Garden Shaft. The Coetia-ball, Picton, or Gyrn-fawr cross-course runs from near Bron-Holloway due south to join the Coetia'r-odyn near

Brynford. The Flingallt and Speedwell range through Bron-Holloway, and the Old Pant-y-nef, which has been worked for some miles southwards, crosses the Old Holloway Vein about 50 yards east of the Old Whimsey Shaft, and runs on northwards to Eyton's Shaft; while lastly the New Pant-y-nef cross-course, lying on the east side of the Grange, and about 50 yards west of the Old Pant-y-nef, passes through the Black Limestone quarry to the Clwt-militia. The Old and New Pant-y-nef cross-courses each throw the strata down to the west, the former bringing Black Limestone against White in a quarry near Coetia-Butler, while both are seen in quarries in the Black Limestone near the Grange. Besides the cross-courses mentioned above several smaller strings have been all more or less superficially explored along the north and west slopes of Pen-y-ball Common.

Continuing westwards we find the Portaway Lode close to the western side of the Grange Quarry, the West Holloway or Golch Hill running nearly through Crecas and under Saith-aelwyd Cottage, the Hopewell on the eastern side and the Lord Hill joint on the western side of Mwdwl-eithin, the last-named running about 200 yards west of Naid-y-march.

The cross-courses enumerated above would, if prolonged, join towards the south near Pen-y-ffordd. As a fact, however, most of them die away, the Old Pant-y-nef alone keeping its course. The New Pant-y-nef has been traced to near Ffrith, 600 yards east-north-east of Calcoed Hall. The deposit of ore would probably have been rich had these lodes converged towards the north, where the Chert passes beneath the Holywell Shales.

A few of them were recognised in the working of the Old Holloway Vein. Pennant saw the Maes-Whitford, True Blue, and Brocnallt (? Coetia-ball) cross-courses in the day-level, and a cross-course hading east, 20 yards east of the Little Engine Shaft, is said to shift Brammock's Vein 6 feet southwards on its east side.

The True Blue Lode, according to the late Mr. Roskell, appeared in both walls of the Holloway Vein, and brought in water from both the northern and southern sides, that from the northern or Coal Measure area being a "Harrogate water" (presumably containing sulphuretted hydrogen), that from the southern or Limestone area being ochry and depositing oxide of iron.[1] The Gyrn-fawr, which seems to be the Coetia-ball lode (and perhaps the Brocnallt cross-course of Pennant), was also described as a strong joint. The Old Pant-y-nef cross-course was struck in Eyton's Shaft at a depth 68 yards, the total depth

[1] The spring flowing into the Old Holloway Vein from the New Pant-y-nef cross-course was known as the 'Big Duke,' that from the Old Pant-y-nef as the 'Little Duke.' These and other springs flowing from north-and-south joints into the day-level were drained by Eyton's Shaft.

of the shaft being 128 yards. The cross-course runs nearly due north to the shaft, but then bends a little to the east, and ranges towards Stockyn Hall.

By 1871 the 128-yard level had been carried 74 yards north of Eyton's Shaft, the 110-yard level 130 yards, and the 100-yard level 125 yards, in the same direction. There were levels at 84 and 90 yards also, on the southern side of the shaft. The branch of the day-level to the shaft was driven through shale, but near the shaft entered the top beds of the Chert, the beds rising slightly northwards, as is shown by the exposure of chert a few yards west of the shaft. The Partridge Shaft was sunk nearly on the intersection of the Old Pant-y-nef and the Partridge Vein, which however splits up into strings on the eastern side of the cross-course.

In 1879 strings connected with the Old Holloway Vein were being worked from a shaft by the north side of the road at Saith-aelwyd. The vein itself had been cleaned out by the 'old men,' the size of the caverns so made testifying to the amount of ore that had been raised. The rock was hard white limestone, dipping north-north-east at 10 degrees to 14 degrees, and partly silicified in the wall of the vein, so as to strike fire; while the vein-stuff, down to a depth of 40 yards, was principally made up of silica, but below that depth of white calc-spar. The strings that were then yielding ore ran nearly vertically downwards, so as to intersect the hanging wall of the Old Holloway Vein. This part of the Old Vein had been rich in calamine, and haded at an unusually low angle.

The West Holloway Mining Company sank a whim-shaft to a depth of 120 yards on the Golch Hill cross-course at a point 180 yards south-south-east of Saith-aelwyd Cottage (under which the cross-course runs), and worked at this depth along the lode northwards into the Old Holloway Vein, along which they explored both to the east and west. At a few yards westwards they found a joint with a little copper and lead striking out of the vein northwards. Towards the south the Golch Hill Lode, near Crecas, splits up into strings, one of which, about 70 yards to the east of the lode, is known as Allsopp's. About 260 yards to the west of the Golch Hill lies the Hopewell Lode, nearly parallel, but getting nearer to it, where it passes through the limestone-quarry on the northern side of the Milwr Vein.

The Lord Hill joint intersects the Old Holloway Vein in an old Black Limestone quarry 150 yards south-west of Celyn Farm. It runs through a limestone-quarry 230 yards east of Pant, and thence, as is supposed, across the Milwr Vein to near Naid-y-march.

Near this point the Old Holloway Vein encounters the Pantasa Fault. The structure of the hollow that marks the position of the fault is imperfectly known, but the information supplied by a former underground manager of the Bog-Celyn Mine shows how completely both the vein and the rocks are

disordered. West of the hollow, the vein is shifted about 150 yards to the south of the point where it was lost in the Bog-Celyn Mine, and runs under Penffordd-bedw and the Druid Inn, and along the northern side of the high-road to Pant-Wacco. The Coetia-eithin Shaft (150 yards north-east of the Druid Inn) was sunk to a depth of 80 yards, and was drained into the day-level that terminates at Tre-Eden-Owen, at a branch vein about 37 yards north of the Old Holloway Vein, which is shifted here about 7 yards northwards on the western side of a small cross-course. The Branch Vein was worked at the 42-yard level, and for a distance of 103 yards at the 54-yard level, east of Coetia-eithin Shaft, as late as May 1904. A sump from the 54-yard level goes down to the 102-yard level, *i.e.*, just above adit-level on the Holloway Vein.

Plantation Shaft, on the Holloway Vein south of Coetia-eithin, sunk to the 100-yard level, a little above adit-level, passes through the hanging wall of the vein at 70 yards. There are old workings eastward at the 40-yard level. The vein had been worked at the 40-yard level for a distance of 103 yards west of the shaft by May 1904. Working was also done on the 70-yard and the 100-yard levels, and completed about the same date, although the latest regular returns of output (13 tons galena and 13 tons blende) are for 1900. One ton of blende was got in 1906. A cross-cut at 100 yards was driven northward beneath the Branch Vein, which, however, does not appear to have been found at this depth. Southward a cross-cut was driven for about 80 feet to old workings on a south branch of the Holloway Vein.

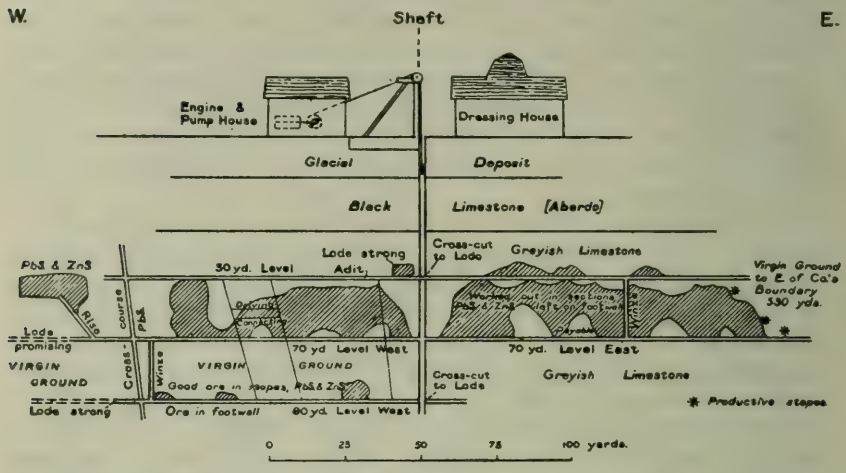
Practically all the mines in the Whitford-Holywell area described in the foregoing pages are now abandoned. The True Blue Mine produced a few tons of ore in 1900 and 1901, and had been worked previous to 1891. The Sir Edward Mine yielded its last output in 1889; whilst North, South, and Old Pant-y-nef Mines had all closed down by, or before, 1890. New Pant-y-nef yielded sparingly until 1903 or 1904. Speedwell and Grange closed about 1887. The latest workings for ore on the Holloway Vein were concluded in 1905–6, as above stated, p. 52. There were numerous separate mines along its course, the majority of which were closed by the beginning of the present century.

The Old Holloway vein has attracted less attention of late years in this part than one running nearly parallel to it, but from 200–300 yards farther north, and known as the Gorsedd or Merllyn Vein.

The Merllyn Vein (Fig. 4, p. 56) has been worked as far west as the Lloc Baptist Chapel, but the shaft was flooded about 1854. Eastwards it was followed across the Pant-Wacco Fault and some other cross-courses under the buildings of Merllyn to the Lady Fielding Shaft of the Lloc Mining Company, 100 yards east of that farm. The vein was worked to a depth

of 60 or 70 yards, but a quantity of ore, reputed to be of the value of £150,000, was raised from a depth of about 20 yards only in 1850. In 1857, though some ore had been found in

FIG. 4.—*Section of Waen or Merllyn Mine, Holywell.*



the Merllyn Shaft farther west, the mine was almost at a standstill. A few tons of ore were raised between 1887–1891 at Rhydwen (Lloc) Mine, and again in 1907. In 1913 operations were resumed for a while, three tons of ore being got.

Near Merllyn Farm the vein seems to divide, one branch, the Gorsedd Lode, having been worked on the southern side of the high-road, while the other, or the Merllyn Lode, ranges towards Waen, but was lost a few yards east of Merllyn. Recent workings at Waen and Merllyn Mine are described on p. 117.

The Gorsedd Vein, in the workings on the south side of the high-road, was shifted by a fault ranging north-north-west, but with a downthrow east. The shift of the vein was therefore southwards on the *eastern* side of the fault.

The latest lead-ore to be raised at the Gorsedd and Merllyn, or Gorsedd and Sinclair United, Mine was got in 1887.

The Milwr and adjoining Veins.—This great vein ranges about E. 20° S. from Pant-Wacco, where it meets the Old Holloway Vein and the Pant-Wacco Fault, to Milwr, about one mile south of Holywell, a total distance of about 3½ miles. The vein throws the strata down many yards on its south side, so as to bring in the Black Limestone and a small patch of Chert Beds on the southern side of the White Limestone of Pen-y-ball. All along this part of its course the White Limestone forms a pronounced feature on the upthrow side of the fault, dominating the lower ground formed by the comparatively

soft Black Limestone; but where the vein passes eastwards into the area occupied by the Holywell Shales, the higher ground lies on its southern or downthrow side.

The richest deposit of ore occurred in the eastern end of the Milwr Vein and in a number of associated strings and joints in the Chert Beds, under the Lower Coal Measure shales, but the earliest workings in the vein lay farther west in the Limestone. They extend nearly continuously as far as Pantasa, and thence at intervals to Pant-Wacco.

The *Milwr Mine* was situated on the eastern end of the Milwr Vein and the associated strings, and was worked as far eastwards as the increasing thickness of shale over the chert would allow. The mine was drained into a day-level, which opens in the southern bank of the Nant-hil-brwc, 600 yards south-east of the Workhouse, and runs thence by Milwr Farm, under Derwen-bâch and Derwen-fawr, to Hwylfa-fer. The level was commenced, according to Pennant, in 1754, with the object of draining the 'hard shaft' vein (Herward Vein).[1] Another day-level runs 70 yards east of Brynford Hall, under the high-road 250 yards south-east of the Workhouse, and opens into Nant-hil-brwc.

The veins worked in this and the adjoining mines will be taken in order from north to south. The Milwr Vein (the Old, or Pant-Ithel Vein of Pennant) runs 80 yards south of Pen-y-bryn, 50 yards north of Brynford Hall, and across the high-road at a point 100 yards north-east of Milwr Farm; where last seen (100 yards east of the road) it underlay to the south at 2 in 3, and ranged towards a point about 100 yards south of Cefn Farm. From 50 to 80 yards south of the Milwr runs a joint known as Woodlands (or Ellis's Vein). The Meadow Shaft between the two passed through 40 yards of shale before reaching the chert. The next vein to the south (sometimes called the Beili-gwyn) runs 120 yards south of Brynford Hall, and nearly under Milwr Farm, ranging thence, parallel with the Milwr Vein, towards Pwll-melyn Cottage. It is nearly vertical at the Milwr Farm Engine Shaft, from which it was reached by a cross-cut of 4 yards; a level driven thence eastwards along it at 140 yards depth enters Lower Coal Measure shale in about 500 yards, the shale, which contains a thin seam of coal, dipping at a steep angle to the north-east. Recent workings on the Beili-gwyn and adjacent veins are described on pp. 124–126.

The Clawdd-ffordd or Cornel-pylle joint runs from Milwr Farm towards the south-south-west, and therefore at an angle with those described above. A shaft upon it by the side of the upper road reached a depth of 120 yards, and Simmond's Shaft, 300 yards farther west, of 116 yards. Davies's Vein runs nearly

[1] 'The History of the Parishes of Whiteford and Holywell,' 4to., *Lond.*, 1796, pp. 254, 255.

parallel to the Milwr along the northern margin of Pen-y-pylle Common, and falls nearly into line with the Old Hwylfa Vein; the last-named was worked from a shaft 140 yards deep and situated 150 yards north-east of Pen-y-pylle. The America Vein (the Rost-y-cegin Vein of Pennant) is nearly parallel to the Old Hwylfa, and runs under Pen-y-pylle House. The Old Herward Vein crosses the upper road 70 yards south of the America Vein, and runs parallel to the Milwr Vein. It is joined at the Herward Mine by the Herward Vein, which runs nearly east and west, with an underlie to the south. The Herward Shaft (Fig. 17, p. 120), near the point of intersection, was sunk to 224 yards depth, and a cross-cut 40 yards in length driven from it to the Herward Vein at 112 yards depth, and another of 48 yards in length at 140 yards depth. The Hard Shaft on the western side of the upper road is 15 yards distant from the 47-yard level in the Herward Vein.

The Old Milwr Engine-shaft (Fig. 17, p. 120), according to an old miner, passed through the following strata:—

	Feet.
Shale (Lower Coal Measures), about	45
Chert	120
Bastard limestone (Black Limestone)	100
White Limestone	—

All the veins enumerated above underlie to the south, except the Beili-gwyn and the cross-vein known as the Cornel-pylle. They seem to have been worked out in the Chert, as far under the Lower Coal Measures as they could be followed, but two only have been detected in the Limestone west of the Chert-outcrop, namely, the Milwr Vein, and the Beili-gwyn, which latter was worked as far as Brynford Hall. Recent workings on some of the above veins are described on pp. 119, 124–126.

At the *Old Milwr Mine*, lead and zinc ores were raised up to 1901, the proportion of blende being highest in the last few years. At Milwr Mine the ores were produced fairly abundantly up to the end of 1912.

The Milwr Vein in its course westwards passes a number of north-and-south cross-courses, besides those which have been enumerated in describing the Old Holloway Vein. Commencing at the eastern end of the vein, we find some joints running north-and-south on the western side of Pen-y-bryn, and 200 yards east of Coetia-mawr we pass the Caleb Bell cross-course,[1] which is popularly believed to run the whole length of the county. This cross-course has been worked across the limestone-hill of Pen-y-bryn, and seems to have been the site of the Pen-y-bryn Mine referred to by Pennant as having been "remarkable for the quantity of refracting spar, *spatum* "*Islandicum*, of great purity and transparency; and often "elegantly infected with marcasite finely disposed in lines,"[2]

[1] Frequently referred to as the Galop or Galopell cross-course.

[2] 'The History of the Parishes of Whiteford and Holywell,' p. 254.

a spar that is common in the cross-courses on parts of Halkyn Mountain. The cross-course then traverses Coed-y-fron and ranges nearly due north under the Red Lion in Holywell towards St. Winifred's Well, of which it was supposed to be the principal feeder. The most northerly shaft upon it lies at the northern margin of Coed-y-fron, and was sunk to a depth of 87 yards, the workings extending to within 21 yards of the level of the spring without finding water. South of the Milwr Vein it has not been worked for about 500 yards.

The next cross-course, known as the Bryniau, lies 200 yards west of Coetia-mawr. It runs from near Ffrith, where it was worked in the Valentine Mine, near the Capel Saron, Brynford, through the Ashton Mine, to some shafts in the Chert Beds 100 yards east of Halfway House. The Pedol-aur Shaft, 200 yards west of Coetia-mawr, was sunk on this cross-course to a depth of 105 yards. The Sir Edward Lode, already mentioned on p. 52, crosses the Milwr Vein 400 yards north-west of Coetia-mawr, and has been worked southwards for about 700 yards. The Frame Shaft, 120 yards south of the Milwr Vein, was sunk on it to a depth of about 100 yards. Near Brynford the Coetia-ball branches out from the Sir Edward Lode, crosses the Milwr Vein close to Smithy Gate, runs through the Picton Mine (180 yards deep), and thence down to Holloway (p. 52). In the Picton Mine a cavern full of water was cut into with so little warning that the miners barely escaped with their lives. The water disappeared in a short time, but St. Winifred's Well was temporarily discoloured. The Coetia-ball is described as a double lode, No. 1 lode lying to the east, and No. 2 to the west, the two running together a few yards south of the Pant-y-rhedyn Shaft. This shaft, which lies 120 yards south of Smithy Gate, intersects the Beili-gwyn (or Clwt-militia) Vein at 60 yards depth, the vein ranging W. 15° N. and hading south. At 86 yards depth, and 14 yards south of the shaft, the Coetia-ball Nos. 1 and 2 intersect the Beili-gwyn. On the eastern side of the Coetia-ball lodes the Beili-gwyn, if correctly identified, is shifted 15 yards southwards, but the true continuation of the vein is probably yet to be found, for the Coetia-ball hades to the east, and should therefore shift the vein northwards. In the 106-yard level also the Coetia-ball lode cuts off the Beili-gwyn Vein, but seems itself also to make a slight shift of 2 yards at the intersection. The Milwr Vein, ranging E. 35° S., is intersected in the 86-yard level at 86 yards distance from the shaft, and in the 106-yard level at 70 yards distance, the southerly slope of the vein therefore amounting to 4 in 5, an unusually low hade. The Coetia-ball at its junction with the Milwr Vein ranges N. 20° W. A supposed continuation of the Beili-gwyn Vein runs through the Pedol-aur Shaft at 70 yards, but underlies north. The water rises in the winter in the Pant-y-rhedyn Shaft to the 106-yard level, that is, about 200 feet above St. Winifred's

Well, but quickly runs off in dry weather, while in the Picton Mine the water is said to stand at about 540 feet below the surface, or only 30 feet above St. Winifred's Well.[1] The 20-yard level in the Pant-y-rhedyn Shaft runs in Black Limestone dipping south-east. The vein-stuff in the Beili-gwyn and Milwr Veins consists principally of white sand and spar, a decomposed silicious deposit; that in the north-and-south lodes of clay with lumps of calc-spar.

We now reach the Old Pant-y-nef cross-course, which runs from Eyton's Shaft (p. 53) through the Milwr Vein at Coetia-Butler, between the two Black Limestone quarries at Clwt-militia, 100 yards east of Ffrith, and so southwards. The cross-course throws the strata down a few feet to the west, and thus introduces a small patch of Black Limestone on the northern side of the Milwr Vein. The Milwr Vein runs on the southern side of a quarry in this patch, the Old Pant-y-nef lying on the eastern side, and a branch from the Milwr Vein, known as the Smith's Bellows Lode, on the northern side of the quarry.

Between this quarry and those at Clwt-militia, two east-and-west veins are termed the Seven Stars and the Clwt-militia.[2] The latter was worked up to the New Pant-y-nef, and there lost. It crosses the Old Pant-y-nef, but is shifted by it 3 yards southwards on the eastern side of the cross-course, as might have been expected from the fact that it underlies south, at an angle of about 40 degrees from the vertical. In the upper part of the mine the vein throws the Black Limestone on the southern or downthrow side against white limestone on the northern side, and contains cherty vein-stuff in the upper part, but calc-spar at a greater depth. The Engine Shaft (778 feet O.D.) on the Clwt-militia Vein is 80 yards deep, and ends 4 yards south of the vein; an engine-shaft on the Old Pant-y-nef, now disused, passes 20 yards north of the Clwt-militia Vein at 80 yards depth. The richest parts of the vein lay at 40–60 yards depth, and especially under a bed of shale, about a foot thick, in the limestone; it was noticed also that the vein was rich where it was joined by 'feeders,' or vertical joints, some of which descended from the hading or foot-wall, while others ascended from the hanging wall, but in neither case carried ore at any distance from the vein. In this mine the average yield of silver to the ton of lead was 10 ounces. Another vein known as the Beili-gwyn runs a few yards north of the Clwt-militia. The Seven Stars was also cut off by the New Pant-y-nef cross-course, but is said to pass the Old Pant-y-nef, with a shift, however, similar to that undergone by the Clwt-militia. The New Pant-y-nef (shaft,[3] 750 feet O.D.; depth, 80 yards) runs from

[1] In 1890.

[2] The information regarding these veins was supplied to Mr. Strahan by Capt. Davies, of the Clwt-militia Mine.

[3] A list of Shafts, with depths, Ordnance Datum, and depths to water is given by Capt. J. L. Francis in 'Evidence before the Select Committee of the House of Lords on the Milwr and District Mines Drainage Bill,' 1904.

near Ffrith between the Clwt-militia Office and the Engine Shaft of that mine, across the Milwr Vein 40 yards west of the Black Limestone quarry previously alluded to, and thence to Holloway (p. 53); it has been worked in a shaft near the top of Pen-y-ball to a depth of 120 yards.

The Milwr Vein so far has had the Black Limestone on its hanging or downthrow side, but in the angle made by this vein and the supposed Lord Hill cross-course some shafts have been sunk in chert and shales with nodules of ironstone, an outlier apparently of Cefn-y-fedw Sandstone and Lower Coal Measures. The *Gladstone Mine* (shaft, 780 feet O.D.; depth, 120 yards), a few yards south of the Crecas white limestone quarry, reached the Milwr Vein, here rich in calamine, at 52 yards depth, and the *Cambria Mine*, 140 yards farther west, reached it at 85 yards, both mines being 120 yards deep. The Hopewell and the Golch Hill lodes are supposed to pass through these mines, and to range towards the Clwt-militia Office. The Milwr Vein then runs under the northern side of the Pantasa Monastery, passing the *St. David's Mine*, which is 80 yards deep. About 300 yards west of the monastery it is crossed by the Pantasa Fault, and seems then to divide into two or more parallel veins, one of which keeps its course straight for Pant-Wacco, and has proved rich in calamine, while another runs farther south, forming the northern boundary of the Black Limestone of Bryn-y-gaseg, and a third branches off at that spot to the *Wacco Mine*. At Pant-Wacco the Milwr Vein runs into the Pant-Wacco Fault, nearly at the same point as the Old Holloway Vein, and ceases to be recognisable.

3. Halkyn Mountain.

Of the number of cross-courses that meet near Brynford, the Old Pant-y-nef alone runs on farther south. It has been worked at Pen-y-ffordd in the *Hazel Grove Mine*, the shaft of which was 80 yards deep, and from which a cross-cut was driven westwards to within a few yards of the range of the New Pant-y-nef, before the mine ceased working through litigation. Thence the Old Pant-y-nef has been proved as far southward as Berthen Farm, a distance of 3¼ miles from Eyton's Shaft. In a field near Gelli-Fowler, where the cross-course intersects an east-and-west vein, two men are reported to have raised ore to the value of £40,000 in a few years. Near Plâs-captain the cross-course follows the crest of a small anticline in the limestone.

The few mines lying to the west of the Old Pant-y-nef call for no particular notice. A small vein running nearly north-east has been tried near Foel-dda, and another having the same direction on the old Race-Course. At Bryn-cloddiau some ore was raised from a small depth about the year 1810, but no regular vein was ever found. The *Gors Mine*, a quarter of a mile farther south, was started with the object of finding the

Pant-y-pydew Vein, but no vein was met with. The *Plasau Mine* (1 mile east of Ysceifiog) was worked about 1840 on a vein running nearly north-east, and a shaft was sunk 40 yards vertically to it and 20 yards farther slanting down it, the vein hading south at the rate of 1 in 3. Three levels, at 30, 40, and 60 yards depth, were driven in it westward for a few yards. A shaft farther east was commenced by chance on a swallow-hole, which had merely to be cleared out to serve the required purpose. Water stood (about 30 years ago) at the 40-yard level in the winter. The *Tyddyn-Shepherd Mine* lies on a vein running about east-north-east.

On the eastern side of the Old Pant-y-nef, and between it and the Caleb Bell cross-course, we find the Pant-y-pydew Vein, the Silver Rake, the Thorntree, and the Wagstaff Veins. The Pant-y-pydew Vein runs from near Pen-yr-hwylfa nearly due west across the Caleb Bell cross-course, hading, and throwing the strata down, to the south. Its course is marked by many shafts, one of which, the Pulley Shaft, lies just west of the Black Limestone outcrop, and another, the Engine Shaft, 120 yards west of the Caleb Bell. They intersected the vein at 60 yards depth, and encountered water at about this level, that is, about 410 feet above St. Winifred's Well. A sump was sunk in the vein for about 30 yards below the Engine Shaft, the vein hading south at 2 in 3. In the field north of the shaft the course of a flat, in which ore was embedded in blue clay, is marked by a line of hillocks. The Silver Rake is mentioned by Pennant as having yielded a green lead-ore. "Only a small "quantity was found, which yielded about thirteen hundred "and a quarter from a ton of the ore. It was of a very "stubborn quality, and resisted the greatest powers of the "blast furnace before it would yield any metal."[1] The ore referred to may have been anglesite (sulphate of lead).

The Silver Rake has been worked opencast from the Caleb Bell westwards for about 300 yards. It has never been proved to run through that cross-course, but a vein having about the same direction was worked 250 yards east of it in the *North Prince Patrick Mine*, with, however, a different spar from that of the Silver Rake, which has a clear amber colour. The East Silver Rake Shaft (834 feet O.D.) is 60 yards deep, and the water stood (about 30 years ago) at about 40 yards depth. The Llwyn-y-cosyn Vein runs parallel to the Silver Rake, but farther west, and 100 yards south of it. The mine of that name was worked in 1877 to a depth of 65 yards and a cross-cut driven northwards at 40 yards depth in an ineffectual search for the Silver Rake. The course of the Thorntree Vein is marked by a few shallow workings from the Caleb Bell for about 600 yards westwards. A shaft 150 yards west of the cross-course was sunk 60 yards, and a cross-cut of 20 yards driven from it to the

[1] 'Tours in Wales,' vol. ii, 1810, p. 68.

Thorntree. The Wagstaff Vein crosses the old Pant-y-nef at Plâs-captain, and is shifted by it a few yards northwards on the eastern side; it has been followed for about 750 yards, but not up to the Caleb Bell cross-course.

The Caleb Bell cross-course, which we have already traced as far south as the Milwr Vein, can be followed without difficulty through the ground just described. Near Brynford it is accompanied by a string known as the Cornel-llwyd, which has yielded some ore; thence it runs 120 yards east of the Pant-y-pydew Engine Shaft, and carries off the water from that mine. The water was popularly supposed to issue at St. Winifred's Well, but some chemical preparation poured into the Pant-y-pydew swallow-holes to test this point failed to re-appear at the spring. The workings on the Coetia-ball Lode, however, are said to have discoloured the water. Five tons of galena were produced at Pant-y-pydew in 1895. The Caleb Bell cross-course completely divides the veins on its western from those on its eastern side, the Pant-y-pydew, and perhaps the Silver Rake, alone crossing it. From Pant-y-pydew it runs 180 yards west of Nant-y-fuwch, past Pwll-melyn, and 370 yards west of Christ Church, Rhes-y-cae, south of which point it cannot be traced.

The belt of ground between the Caleb Bell cross-course and the Lower Coal Measures includes the richest part of the mineral tract of Halkyn Mountain. Commencing at the point where we left it (p. 59) after describing the Milwr Mine, we first meet the Pen-yr-hwylfa Vein, which runs nearly north-east from Pen-yr-hwylfa to Derwen. It has been worked in and below the Chert to a depth of 80 yards at its western end, and of 110 yards at the North Henblâs Mine. An account of the Milwr Tunnel and of the veins cut by it is given on pp. 118–124. An engine-shaft commenced at Derwen-fawr traversed the following beds:—

	Feet.
Gravel and clay (Glacial)	15
Black shale	6
Two bands of cement-stone (black argillaceous limestone), and three of bastard cement-stone, separated by beds of black shale ... ... about	15
Black bastard chert	—
	36

The shales with cement-stones (Holywell Shales) are exposed to view in the lane close by. Roskell's Day-level, which runs through the Herward Mine, passes under Derwen-fawr at a depth of about 90 yards.

The Pant-y-pydew Vein also runs past Pen-yr-hwylfa, turning to the south-east between Pen-y-garreg and Henblâs farms to the *Cacau* and *Llongle Mines*, each of which passes through Holywell Shales with cement-stones into the Chert Beds to a total depth

of 120 yards.[1] A cross-cut was driven from a point in the vein 300 yards north-west of the Caeau Engine Shaft towards the termination of Roskell's level at Hwylfa-fer, but at 30 yards above it.

The portion of the Chert-escarpment known as Pen-yr-Henblâs has proved exceedingly rich in lead-ore, and has been riddled with the mining of the irregular joints and cracks into which the veins so often split on entering the Chert. There seem to have been four leading veins running about north-east, and two running nearly east-and-west, all hading to the north. Of the former the Garreg-llwyd or Hugh Pierce Vein in the north was worked on the hill from a shaft 140 yards deep; the Cross Leavings and the True Blue, a little farther south, have been trenched on the surface; while the Old Henblâs Vein was worked in Hooson's Shaft, and in a shaft, 160 yards deep, at the old mine-buildings on the eastern side of the hill. Mather's or Sankey's Vein runs a little south of east, 50 yards south of these buildings, and the South Vein, a little north of east, 100 yards south of the same point. In the hollow between this hill and the Caleb Bell Vein, a cross-course has been worked, in part in open trenches, under the name of Pwll-y-gaseg. It follows the township-boundary from near Pant-y-pydew to Nant-y-fuwch, where it joins the Caleb Bell. It was proved under the township boundary in the North Prince Patrick Mine, and seemed to cut off the Silver Rake altogether, for a cross-cut driven from Bishop's Whim Shaft near by, for 200 yards along the eastern side of the Pwll-y-gaseg, failed to prove any vein.

Parry's Mine lies in a flat running north-and-south across the high-road 600 yards west of Halkyn Hall. The shaft (now fallen in) by the road-side was 110 yards deep, and from it the flat was followed northwards for about 250 yards to a depth of 140 yards, when it was lost, the solid rock closing it on all sides. The old hillocks of this and other mines near contain crystals of transparent spar with needles of copper pyrites embedded in them. Farther east lies a nearly east-and-west vein, which many years ago was worked 200 yards north-west of Halkyn Hall, under the name of Parry's Vein, to 125 yards depth. Grainger's Vein runs a little south of east on the northern side of the Hall.

The Pant Vein runs from the Caleb Bell cross-course, 50 yards south of Halkyn Hall, through Sir George's Field at Pentre-Halkyn, a distance of about $1\frac{1}{8}$ mile. Towards the west it falls nearly into line with the Thorntree Vein, and like it hades to the south. Its course is marked as far as the Engine House of the Prince Patrick Mine (at the base of the Chert Beds) by a hollow studded with innumerable hillocks, the result of shallow workings along the 'back' of the lode. From the Engine Shaft

[1] This shaft has been deepened. *See* New Caeau Mine (p. 126).

it was explored about 200 yards westwards at 120 yards depth, but was found to be heavily watered. From the same shaft a level was driven about 80 yards eastwards at a depth of 100 yards, and served to conduct the water from the Prince Patrick Mine to some swallow-holes in the Pant Lode; the vein-stuff consisted chiefly of white sand and 'tuft' (a decomposed silicious vein-deposit), while the vein haded south at about 1 in 3. Little or no ore was obtained in these workings in the Pant Lode. Sir George's Field, however, yielded a vast quantity of lead-ore, and seems to be the spot alluded to by Pennant, who says "the "richest vein was discovered about fifty years ago [about 1728] "at *Rowley's* rake, or *Pant y Pwll dwr* on Halkin mountain, "continued with some interruption into a small inclosure, the "property of Sir George Wynne . . . . .; which in less "than thirty years yielded to different proprietors, adventurers, "and smelters, above a million of money."[1]

The field alluded to lies 400 yards east of Halkyn Hall; the workings were drained by a day-level opening into Nant-y-Flint, near Plâs-isaf (Bryn-gwyn on the one-inch map, 79 S.E.). The Engine Shaft (now filled up) was situated 180 yards south-south-west of Springfield, nearly on the junction of the Pant Lode with a string that runs east-north-east from Billins. No ore has been raised of late years from the Pant Lode, but rich flats close to it have been worked with considerable profit in the *Prince Patrick Mine*.[2] The ore lay in pipes, or enlargements along a joint running north and south. The first pipe discovered was exhausted previously to 1877, and is now referred to as the Old Flat. The New Flat, found soon after, was worked out in 1880. The two fall into the same line and form in reality one continuous flat. Taken as a whole this flat, or pipe, slopes down towards the north with a gradient of 1 in 8, the depth to it at Hughes's Shaft being about 80 yards, and at the Engine Shaft 105 yards. It intersects the Pant Lode a little east of the Engine Shaft, and was followed a few yards north of the lode, but there lost, though search was made for it to a depth of 170 yards. It falls nearly into line with Parry's Flat previously described, but would, if continued, pass below it. Similar pipes (lying at a low angle) have been partially explored farther south also, in the *Queen of the Mountain Mine*, but without the discovery of another body of ore. The pipe, where it had been opened to view in the Prince Patrick Mine in 1879, was bounded on all sides by rounded walls of solid limestone, except in the roof and floor (which form two of the sides of the pipe), where could be seen a joint, to which no doubt the cavity owed its existence. The pipe was about 8 yards wide and was filled with beautiful calc-spar (sometimes stalagmitic), more or less

[1] 'Tours in Wales,' vol. ii, 1810, p. 69.

[2] Mr. Strahan's examination of this mine was made under the guidance of Capt. Verchoe.

transparent, and containing needles of copper pyrites;[1] while down its centre ran a band of galena, somewhat irregular, but reaching a thickness of 2 feet. The band of galena, lying as a bed in the pipe (not as a vertical rib), followed it at a distance of about 4 feet from the floor, so as to present much the same appearance as a coal-seam in a colliery-level. It tapered away, however, on both sides towards the walls of limestone. The flat lies at about 100 yards below the base of the Chert Beds, in dark-grey limestone.

The Prince Patrick Mine yielded the following quantities of ore :—

Year.	Tons.	Year.	Tons.	Year.	Tons.
1872	117	1877	220	1882	31½
1873	214	1878	79	1883	15
1874	510	1879	625	1884	5
1875	606½	1880	240	1885	16½
1876	204½	1881	23¾	1887	3

Some small east-and-west strings, known as Taylor's, Phillips's, the Maen-bras, and Bolly's Lodes, run through the southern part of the mine, and have yielded small bunches of ore here and there at slight depths. The Maen-bras is intersected in the Rule Shaft (80 yards deep), but has not been thought worthy of exploration. A cross-cut driven into Bolly's Lode was continued along the lode to its intersection with the flat (60 yards south of Rule Shaft), proving it to be here 4 or 5 yards wide, but to contain clay and spar only. Bramwell's Vein is another small string that has been worked to a shallow depth ; its continuation into the Chert has been unsuccessfully sought in two shafts, and in a cross-cut that was driven at 90 yards depth towards Billins from a shaft 200 yards west of Halkyn Terrace.

The China Rake (shaft, 767 feet O.D.; depth, 140 yards), which forms one of a cluster of nearly east-and-west veins, underlies north. It is supposed to cross the Caleb Bell at Pwll-melyn, but has not been worked farther west than the Grosvenor Mine, which was 100 yards deep. Eastwards it branches into the New and Old Chwarel-lâs Veins, the former of which was worked under the Black Limestone outcrop to 91 yards, the latter near the same spot to 180 yards depth. Some small north-and-south joints, filled with spar with needles of copper-ore, cross the veins here and there. The Dogpit Vein ranges from near the Grosvenor Mine, a little south of east.

The Union Vein, underlying south, runs from near Fron rather south of west, 250 yards north of the Foel-ddu fireclay-

[1] Out of the masses of calc-spar thrown out on the hillocks, could be obtained perfect and transparent rhombohedra, through which the needles of copper pyrites run in bands, each needle being usually placed at right-angles to its band. The bands seem to have no relation to any of the cleavage-planes of the rhombohedron, but they are probably parallel to one of the planes of accretion of the original crystal of which the rhombohedron forms a fragment. The bands occasionally cross one another obliquely.

pit. It has been worked both in open trenches and to a depth of 80 yards at its western end, and yielded calamine. At 150 yards west of the Chert-boundary it is intersected by the Wagstaff Lode, and at that boundary by the Vein Crwn (or Pwll-gwyn-llan), both of which contain spar with needles of copper pyrites, and have been traced southwards as far as the Long Rake, the principal shafts on the former being 60 and 80 yards, and on the latter 110 yards deep. The last output from Pwll-gwyn-llan was for 1890. The Union Vein runs on the eastern side of the Vein Crwn through the Mary Jane Shaft to an old whim-shaft (since fallen in) near Fron.

The Long Rake underlies north and runs from the Long Rake Engine Shaft, 300 yards north-east of Christ Church, Rhes-y-cae, to an intersection with the Vein Crwn, a distance of about two thirds of a mile, or twice that distance if the Gin Vein, Catch Lode, and Long Rake be all considered as one lode. It has yielded ore both at a depth (180 yards at the Long Rake Mine) and up to the surface, and its position is marked for most of its course in the limestone by open trenches, some of which are attributed by tradition to the Romans. Ore was produced at East Long Rake Mine up to 1884. Where it is crossed by the Vein Crwn it branches into several strings, which yielded ore for about 12 yards down from the surface. Three strings also branch off towards the west-north-west, the central of which is known as the Rhyd-y-goleu. East of the Vein Crwn a lode, falling nearly into line with the Long Rake, has been worked under the name of the Gin Vein. At Pen-y-bryn the Gin Vein meets the Pant-y-ffrith cross-course, and is either cut off or displaced by it, for the Catch Lode, which seems to be the same vein, lies 30 or 40 yards farther north. The Catch Lode has been worked at Pen-y-bryn (shaft 855 feet O.D.; depth 209 yards) and was intersected at 120 yards depth in a shaft 100 yards north-west of the Wesleyan Chapel (Fig. 5, p. 69).

About the years 1905–6 a branch from the Halkyn Tunnel was driven north-westward from the Lewis Shaft on Crockford's Lode to intersect the Catch Lode at the 203-yard level in Pen-y-bryn, and it struck the level at a point 247 yards east of the foot of Pen-y-bryn shaft. It is stated that, although the Catch Lode was not located, a new vein was discovered, but this carried little or no ore at this depth.

Lead from this mine (*New North Halkyn*) was raised in 1905 and sold in 1907, and the last work done was in 1915. All the ore got in this period, comprising 466 tons of galena, came from the Catch Lode above tunnel-level. Two rises, one east and one west of the tunnel-extension, were put up a considerable height. Ore was being won at the top of the western rise in 1912 and 1913. These operations broke upwards into old workings. Fluorspar occurs at Pen-y-bryn in the east-and-west veins.

The Chert and Limestone of the neighbourhood of Halkyn have yielded large quantities of ore from some north-and-south lodes, the productiveness of which may be due to the fact of their crossing the strike of the strata obliquely, so as to pass from Limestone under Lower Coal Measures towards the north. The cross-courses of the Limestone-tracts west of Mold and Nerquis on the other hand, which run along the strike, and in limestone for their whole length, have proved barren. The principal lodes are the Hên Rake (Old Rake), the Pant-y-ffrith, and Crockford's or the Deep Level Lode.

The Old Rake underlies west and runs from Pen-y-bryn northwards, 100 yards east of Fron, where it was known as the Dingle Vein. The old shafts upon it are all either filled up or fallen in. At Pen-y-bryn the workings are reported to have been drowned out at 140 yards depth. Crockford's Shaft, 200 yards south of the building known as Hên Rake, reached the vein at 140 yards depth. The old Engine Shaft lies 100 yards north of the Hên Rake. At Fron the vein was worked in the Dingle Shaft, which lies nearly on the line of the Bryn Parade Vein, a small vein nearly parallel to, but 100 yards south of, the Union Vein. The last output was for 1889. The last shaft on the Dingle Vein lies 180 yards north-east of Fron, the shafts south-east of that spot having been sunk on strings running about north-east through the fields on the northern side of Old Hall. North of Pen-y-bryn the Pant-y-ffrith cross-course underlies west; but at Pant-y-gôf, farther south, it underlies east, at the rate of 1 in 8. The southernmost trial upon it, known as the Wern Shaft, lies in an inlier of limestone near Wern-y-gaer, and passed through six yards of white clay and loose ground into limestone. At the chert-boundary the vein has caused a hollow filled with clay. It then crosses the Pant-y-gôf and California Veins, and runs 60 yards west of Pen-y-bryn, 250 yards south of which house a whim-shaft was sunk to a depth of 140 yards. At Pen-y-bryn the Pant-y-ffrith Lode seems to fall into line with the Old Rake, but according to the miners keeps farther west, passing 100 yards west of Hên Rake.

From the *Wern-y-gaer Mine* a level at 200 yards depth has been driven north-westward along a cross-course that hades south-westward. At a distance of 400 yards from the shaft an east-and-west lode was cut, hading southward, and throwing the Wern cross-course a few yards to the west. The latter carries on through the Plâs-Winter Mine, where the South Level (p. 128) is driven along it. Little or no ore was found. From Wern-y-gaer the driving was run south-eastward also as far as the Halkyn Tunnel, which is at a slightly different level.

The Pant-y-ffrith cross-course and the Old Rake have long been noted for the occurrence in them of tree-trunks at great depths. Such discoveries seem to have been not uncommon in these and other lodes in this district,[1] *e.g.*, at Cat Hole (p. 90

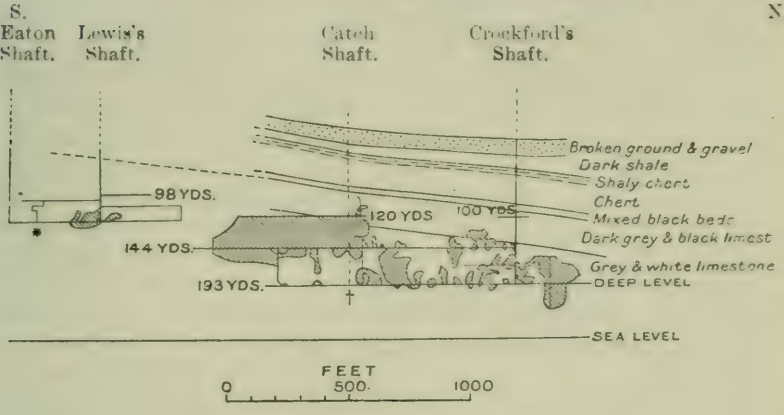
[1] 'Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, pp. 178, 179, 190.

and Pl. III), and in a vein near Crockford's Shaft. They are all probably due to collapse of the limestone and engulfing of the surface.

The Cornel-y-cae Shaft was sunk on a supposed cross-course 100 yards east of the Pant-y-ffrith, near a clay-filled hollow.

The Pant-y-gôf Vein runs from the northern side of the mound of Moel-y-Crio in a north-easterly direction through the Pant-y-gôf Mine, to the Deep Level Lode (Fig. 5, below). Near

FIG. 5.—*Section of Deep Level Mine, Halkyn.*



* Junction with the Pant-y-gôf Vein.
† Junction with the Catch Vein.

The Catch Shaft stands 390 feet behind the line of section.

the Engine House it throws off on its northern side a branch which, under the name of the California Vein, runs nearly east and west. Shafts on the California Vein are Moel-y-Crio at the western end and Mount Halkyn or West Halkyn farther east.

The vein has been worked several times. The Central Halkyn Mining Co. worked presumably from Moel-y-Crio Shaft, between the years 1901 and 1906, when the mine was carried down by shaft inclines to the 198 (? 168) yard level and 174 tons of lead-ore obtained. The vein hades southward at about 45 degrees. A driving was made for 55 yards eastward at the 120-yard level; another for 27 yards westward at the 148-yard level, and ore got; and for 63 yards westward at the 168-yard level. Ore was got between the last-mentioned levels. Above these there are thought to be stopes made by the 'old men.'

The mine was taken up again in 1910, and about 1912 or 1913 a cross-cut made from Mount Halkyn Shaft towards the Pant-y-gôf Vein, but the latter was not found. Ore was found, however, on the California Vein just west of the shaft at 156 yards depth. Much of the ore occurred as lumps of galena in clay, and as grain-ore, and was sent out to West Africa. Other ore raised between 1911 and 1916 went to home smelters. It

was hand-washed and averaged 82–83 per cent. of lead. No blende occurred in this mine at this date, but 24 tons were got in 1888–1889.

A cross-cut southward from Moel-y-Crio Mine found two lodes, presumably the California and the Pant-y-gôf; on the former a driving of 100 yards was made westward. The principal shafts upon the Pant-y-gôf Vein are the Trustees, near the Engine House, the Pant-y-gôf Shaft, 200 yards north-east of the Engine House, and Eaton's Shaft, at the eastern end of the vein. From Eaton's Shaft a level was driven at 174 yards depth in the one direction to the Pant-y-ffrith cross-course (about 600 yards), and in the other to the Deep Level Lode (70 yards); the deepest workings extended to 230 yards depth. The Pant-y-gôf Shaft was 208 yards in depth. From the bottom of the Trustees Shaft (in the 174-yard level) to the Pant-y-ffrith Lode is 100 yards, while from the top of the shaft to the top of that lode measures 122 yards, from which data the underlie of the cross-course has been calculated. The Pant-y-gôf Vein runs eastwards into the Deep Level Lode, which takes its name from the fact of the Halkyn Mountain Deep Level having been driven along it. The level lies 216 yards below the surface at Lewis's Shaft, 150 yards north-east of Eaton's Shaft. A level was driven westward, about 1904, on the Pant-y-gôf Vein at tunnel-level, with no result, the producing ground lying at a higher level.

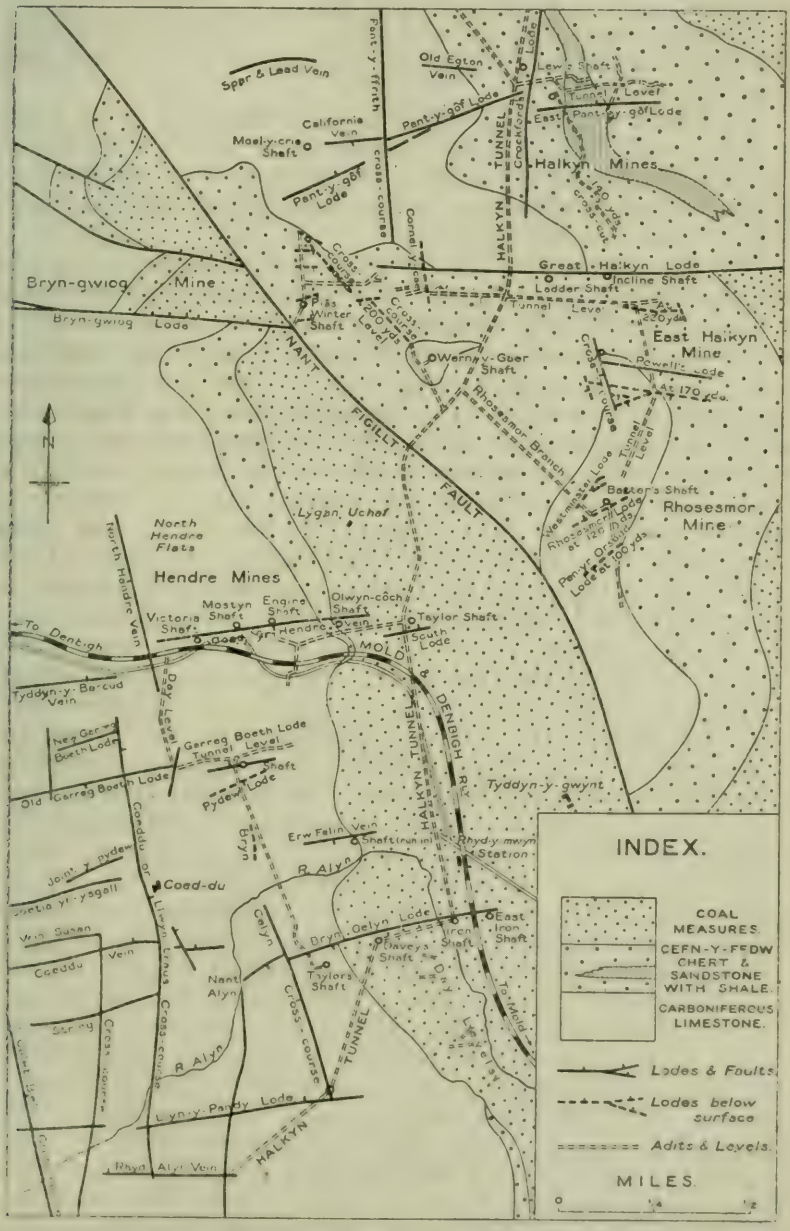
The Pant-y-gôf Vein is shifted 5 yards northwards on the eastern side of the Deep Level Lode, as might have been expected from the fact that the lode underlies west. Recent workings on the east side of the Deep Level are described on pp. 128–134, 137.

The Deep Level Lode runs from near Berth-ddu to a point about 100 yards east of Halkyn Castle. It was worked in the Bryn-y-mawn Shaft, 140 yards deep, in Lewis's Shaft, which cuts it at 80 yards (and also at 180 yards) depth, and again in Crockford's Shaft (about 200 yards south of Halkyn Castle), which was 213 yards deep. A good output was obtained in the 'sixties' and 'seventies' of last century. The last ore got from this lode was raised between the years 1883 and 1886, when a few hundred tons of bunchy ore were found in runs. A trial is to be made from Lewis's Shaft in the higher part of this lode where it traverses the Cherts. The 90-yard (? 98) level was opened in September 1919. The lode at this level traverses grey and dark limestone and shale, with calc-spar and cubes of copper pyrites. A rise is to be put up into the overlying Cherts. Between the 120-yard and the tunnel-levels the hade of the vein was about 4 in 1.

The day-level from which the lode takes its name was commenced in 1818, and was driven from the stream at Bryn-moel, near Coed-y-cra, at a height of 200 feet above O.D., running into the Deep Level Lode near Crockford's Shaft at a depth of about 190 yards.

In 1875 a new company was formed for the purpose of extending the level, and an Act of Parliament obtained, giving

FIG. 6.—*Map of Drainage-Area and Lodes, Halkyn.*



them power to levy a rate on the various mines benefited (p. 23). By this company the level was extended along the Deep Level Lode and southwards in the same line for 1,000 yards, and

thence in a direction about S. 24° W. to a point 30 yards north of the South Pant-y-gôf Shaft, near Wern-y-gaer. From this shaft the level was continued in the same direction for about 360 yards, while a branch, of more immediate importance, runs south-eastwards to Rhosesmor (Fig. 6, p. 71). The level lies 200 yards below the surface at South Pant-y-gôf, and the shaft sunk to it passed through 25 yards of Cefn-y-fedw Sandstone before reaching the Limestone.

At a point 970 yards south of Lewis's Shaft the level intersected a well-defined east-and-west fault with a downthrow south, and containing blende and galena. The workings in this vein since its discovery in the Deep Level have met with great success (pp. 131, 132, 137).

The *Rhosesmor Mine* lies in the inlier of limestone on the southern side of Moel-y-gaer. The strata assume the structure of a gentle anticline or arch, so that the levels, which are driven in massive limestone in the central part of the mine, pass into higher beds, consisting of unproductive shale and argillaceous limestone, at both ends. The principal vein runs about east-north-east and underlies north, but is in places vertical, or even underlies south. It has been worked by the Engine (or Ellis's) Shaft (146 yards deep), at the western end, by Bather's or Batter's Shaft (158 yards deep; 746 feet O.D.) 150 yards farther east, and by Roberts's Shaft (about 145 deep) at the eastern end of the mine, the workings extending a distance of about 400 yards.[1] Ellis's Shaft, which has fallen in since 1879, was 12 yards north of the 100-yard level in the vein, and 8 yards north of the 120-yard level. The 100-yard level followed approximately the junction of the shaly unproductive strata with the productive massive limestones, but the former are thrown down by the vein to a slightly lower level on its northern than they lie on its southern side. In the shaly beds the vein is ill-defined, but in the massive limestones shows cleanly cut hanging and hading walls. About 35 yards west of Ellis's Shaft the shaly beds descend below the 100-yard level and cut off the vein, but at the lower levels the productive beds extend farther west. Similarly the shaly beds intersect this level at the eastern end of the mine near Batter's Shaft, and the 120-yard level about 50 or 60 yards east of Roberts's Shaft. Levels have been driven through the mine also at 120 yards and 140 yards depth, proving the vein to be rich at these depths, but below 140 yards the water became too copious for further exploration, and the mine remained inactive until the completion of the Halkyn Deep Level. After this date Batter's Shaft was sunk to tunnel-level, 170 yards, and the mine worked to that depth. The ore is said to have failed at tunnel-level. The mine was worked until about 1901, when the present East Halkyn Co.

[1] 'The Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, Fig. 20, p. 181.

took it over (p. 134). From the 100-yard level a cross-cut was driven northwards, with the result of proving other veins nearly parallel to the main vein, the principal being the Grosvenor (? Westminster), which ranges about south-west, and hades to the south-east. A cross-cut driven southwards from the 120-yard level for about 24 yards led to no discovery. The crown of the anticlinal arch formed by the strata lies about 50 yards west of Batter's Shaft, and the depth of shale and black limestone at that point is 97 yards. The proportion of silver in the ore of this mine varied from 10 to 13 ounces per ton.

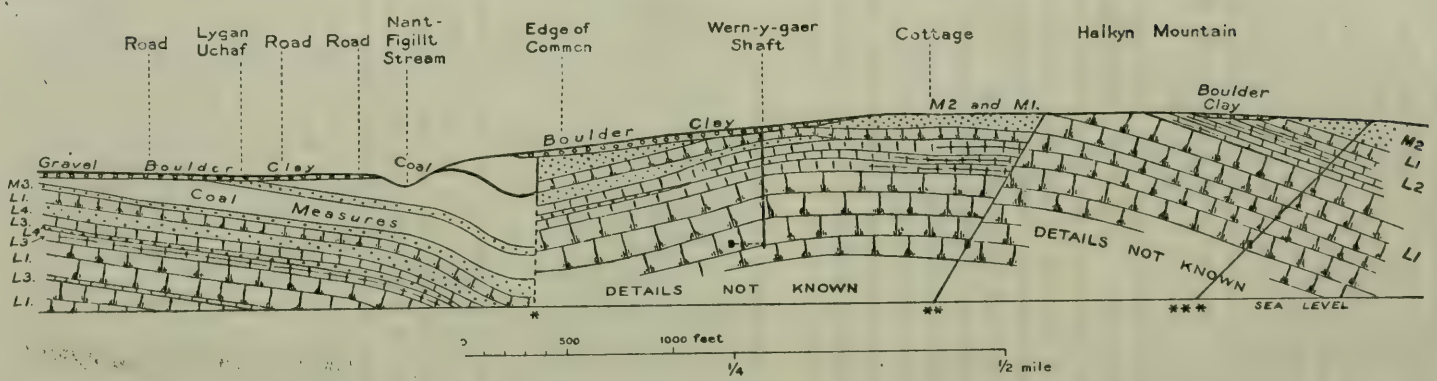
The *Pen-yr-orsedd Mine* lies about 300 yards south of Rhosesmor on a nearly parallel vein. The workings extend to a depth of 170 yards. On completion of the Rhosesmor branch of the Halkyn Tunnel a level at this depth was driven south-south-eastward to the Pen-yr-orsedd Vein, which hades southward and was worked extensively to tunnel-level until about 1901. The tunnel-level was driven farther south for a total distance of 480 yards from the Rhosesmor Vein.

A driving westward on the Pen-yr-orsedd Vein crossed the Nant-figillt Fault, where the white limestones give place to thin beds of dark limestone and shale dipping to the south-west.

4. Bryn-gwiog to Rhydymwyn.

We now cross the fault and deep syncline of Nant-figillt (Fig. 7, p. 74) and mount the escarpment of limestone that includes the Hendre and Mold Mines. The *Bryn-gwiog Mine* lies at the northern end of this tract, near the commencement of Nant-figillt. The vein runs nearly due east-and-west, and throws the strata down on its northern side, shifting the outcrops thereby about 550 yards. As a consequence the Cefn-y-fedw Sandstone and Lower Coal Measure shale in the northern or hanging side are brought face to face with Limestone in the southern or hading wall of the vein, so as to render the tracing of the vein on the surface an easy matter. At its western end the vein appears first as a number of strings in the limestone near Herseld, but about 300 yards farther east becomes a well-defined fissure, underlying north at about 2 in 5. The lowest level lay at 225 yards depth, and the Engine Shaft to it, commencing in shale, passed through the Sandstone, here very thin, and cut the vein at 140 yards. A second Engine Shaft, 200 yards farther west, was sunk in the Limestone and met the vein at 120 yards depth. Towards the east the vein disappears in the Lower Coal Measures of Nant-figillt, the point at which the 200-yard level ran into the shale lying 200 yards east of the Engine House. An attempt was made to find the vein on the eastern side of the nant at a point 250 yards south-east of Plâs-Winter; a shaft was sunk to 80 yards depth, and a cross-cut driven from it to the south-west, but without success (p. 128).

FIG. 7.—*Section across Nant-figillt and Southern end of Halkyn Mountain.*



M1. Sandstone. } Cefn-y-Fedw
M2. Chert } Sandstone.
M Pebbly Grit }

L1. White and Grey Limestone.
L2. Thin-bedded Grey and Dark Limestone and Shale.
L3. Thin-bedded Limestone.
L4. Calcareous Sandstone.

* Nant-figillt Fault. ** Moel-y-gaer Fault and Great Halkyn Lode. *** Deep Level or Crockford's Lode, crossed obliquely by the line of section. The position of the Halkyn Tunnel on the Deep Level Lode, and that of the tunnel-level on the Great Halkyn Lode and in the Wern-y-gaer Mine, are indicated by black rectangles.

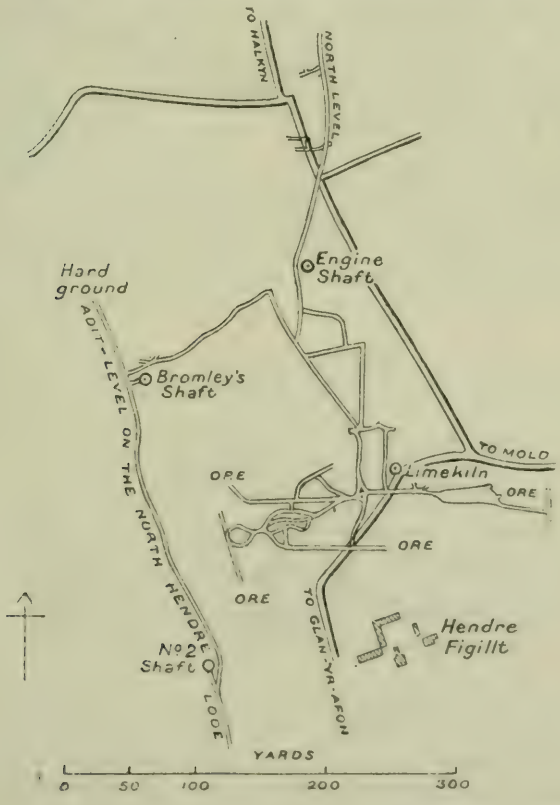
Fluorspar, sometimes blue, and barytes occur abundantly in the old hillocks of this mine and blende or calamine seem to have been more plentiful than galena, blende being especially abundant in the eastern and calamine in the western end of the deeper levels.

In 1860 the lode in the 130-yard level east was 4 feet wide, yielding small lead-ore and blende, worth at that date £30 a fathom.[1]

There is said to be a considerable quantity of blende left in this mine, but the high proportion of fluorspar in the vein is detrimental.

About 300 yards north of the Bryn-gwiog Vein we find surface-indications of a fault presenting many points of similarity

FIG. 8.—*Plan of Workings in the North Hendre Flat*, 1879.



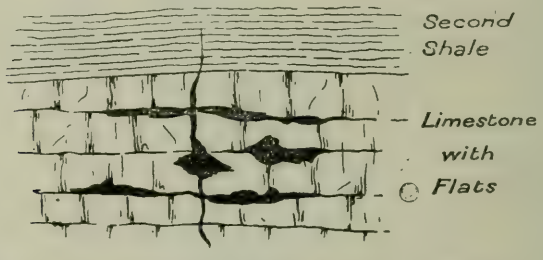
to it. The ground has remained unexplored, the only cross-cut driven north from Bryn-gwiog stopping short of the supposed line of fault. South of Bryn-gwiog lies the Bryn-côch Vein

[1] James Croft, 'A Mining Tour in North Wales,' *Min. Journ.*, Sept. 1860.

(shaft, 808 feet O.D.; depth, 87 yards), and to the south-west the Fron Vein (said to have contained 11 to 12 ounces of silver per ton of galena; shaft, 85 yards deep), neither of much importance. The latter is crossed by the small cross-course of Rhewl, and by a bed of shale with nodules of ironstone, which crops out west of Hersedd. It ranges towards Pen-y-gelli, where some large open spaces in the limestone are by some taken as evidence of the continuation of the Caleb Bell cross-course. The neighbourhood of Hendre produced large quantities of lead-ore till about 40 years ago.

The *North Hendre Mine* (Fig. 8, p. 75) is situated on a lode that underlies west, and runs a little west of north, 100 yards west of Hendre-figillt. Bromley's Shaft, 300 yards north-west of that farm, cut the lode at 68 yards depth. The lode dies out north of the shaft, but southwards runs out into the Hendre Valley 100 yards below the mill-pool, in a ravine caused by the outcrop of a bed of shale. A day-level was driven to the mine from this point. The mine was worked up to about 1894, and derived nearly the whole of its large yield of galena from a flat lying on the eastern side of the lode. As seen in 1879 the flat consisted of a number of pipes or caverns hollowed out in one of the beds of limestone, and running in various directions, each pipe following a small joint visible in the roof, and coming to an end when the joint died out. The flats are also described as occurring as nearly horizontal plates and pockets of ore beneath a roof of shale (Fig. 9, below), on

FIG. 9.—*Section (diagrammatic) showing Flats in North Hendre Mine.*



either side of, or along, vertical joints, little ore occurring on the vertical joint itself. The regular flats were of fairly constant thickness up to 3 feet, of considerable width, and extended for several yards down dip. They were not confined to one post of limestone. More irregular pockets also occurred, occasionally running upwards into the shale. One pocket, by no means the largest, contained 2,000 tons of ore. A little blende occurred with the galena. They contained much brown calc-spar in clusters of radiating crystals, but 'tuft,' a silicio-calcareous vein-stuff, was usually associated with the richest

deposits of galena. The galena contained 5 to 7 ounces of silver per ton and occurred generally in great lumps, while in the eastern and western workings black oxide of manganese ('blacking') lay as a bed in 'tuft' and yellow clay. Some of the spar contained needles of copper pyrites, and needles of galena also, from 1 to 2 feet in length, are reported. The strata (grey and encrinital and coralline limestones) and the system of pipes forming the flat, sloped generally towards the east or east-south-east, at a gradient of 1 in 7. Access was gained to the flat by means of an Engine Shaft 110 yards deep, 300 yards north of Hendre-figillt, the shaft, according to a statement by Capt. Ellis, traversing strata of approximately the following thicknesses:—

North Hendre Engine Shaft.

	Feet.
Gravel (Glacial)	15
Black limestone	8
Grit	24
Black limestone, the same rock as that of the quarry at Hendre	60
Shale	17
Black limestone	60
White limestone, the rock that forms the lower part of the quarry	120

The Coed-Hendre Vein (p. 139) runs a little north of east on the northern side of the Hendre Valley. A description of the old workings is included in the account of the recent mine (p. 138).

West of, and nearly in line with, the Coed-Hendre runs the Tyddyn-y-barcud Vein (p. 143), which has been worked from the southern side of the high-road near the mill-pool, by Efail-Parcy, at a point 150 yards south of the Royal Oak, and through Cwt-coed. It is a strong vein underlying north, separated from the Coed-Hendre vein by a cross-course. It was worked from 7 shafts: Roberts's, 29 yards deep; Pritchard's, 37 yards 1 foot deep; Eyton's, 59 yards deep; Williamson's, 61 yards deep; Marquis, about the same depth; Tyddyn-y-barcud, 75 yards deep; and the shallow Ddol shaft near the cross-course.

The western end of the mine from Williamson's Shaft was drained by the Cycoed day-level, 14 yards depth at Eyton's Shaft. Ore was got at the 40-yard level in Eyton's Shaft, and at and above the 57-yard level on both sides of Williamson's Shaft. A shoot of ore, commencing near the surface on the eastern side of this shaft, ran to Marquis Shaft, where it occurred down to the 40-yard level. In Tyddyn-y-barcud Shaft it occurred west of the shaft above the 40-yard level and down nearly to the 70-yard level. Ore was stoped above the 70- and 50-yard levels also, east of the shaft.

The New Garreg-boeth Vein (p. 143), which runs through the wood of that name, and about 300 yards south of the Tyddyn-y-

barcud, underlies north, and ranges about E. 15° N., like the rest of the veins in this portion of the Limestone-escarpment. At its eastern end it is lost in the Coed-du cross-course, while 300 yards to the west it splits up into strings, and has not been followed. The Engine Shaft upon it was 120 yards deep, and was drained into a day-level, which opens into the Hendre stream, near the Independent Chapel, Glan-yr-afon. In the debris at the western workings, blende, and in that from the Coed-du cross-course, traces of copper, have been seen.

Next on the south to the New Garreg-boeth, and 180 yards from it, lies the Old Garreg-boeth Vein, which runs through the Mwyn-bwll Mine, and towards its western end is known by that name. This vein underlies south, and has been traced for about 1,400 yards, to a point 500 yards west of Mwyn-bwll. At Mwyn-bwll the vein is crossed by a north-and-south lode, which runs down to Hesp-Alyn, and is believed by the miners to be the Caleb Bell cross-course. The cross-course underlies east, and the vein south, the result therefore being that the vein is shifted to the north (about 7 yards) on the eastern side of the cross-course. Farther east the vein has been worked from shafts of a depth of 75 to 80 yards, the Engine Shaft being situated near the eastern side of the Coed-du cross-course. The mine was drained by a day-level driven eastwards in the vein to a point under the road 250 yards north of Plâs-Wilkin, where a third cross-course (probably the Nant-Alyn cross-course) was encountered, running a little east of north, underlying east, and shifting the vein 10 yards northwards. From this point the level turns north to the New Garreg-boeth. Tradition attributes the old workings on the Mwyn-bwll Vein to the Romans. Workings on the eastern part of this lode, which hades northward, are described on pp. 143–145.

The next veins to be described lie between the so-called Caleb Bell on the west and the Coed-du cross-course on the east. The Joint-y-pydew is marked by a line of hillocks in the wood, 200 yards north-west of Coed-du. The Coetia'r-ysgall lies 50 yards south of the joint, and has been trenched out at the surface; the white calc-spar of the so-called Caleb Bell lode has been seen at the western end of this vein. The Vein Susan lies 200 yards south of the Coetia'r-ysgall, and runs from near the Caleb Bell 400 yards eastwards. The Cefn-Cilcain or Coed-du Vein, a more important lode, runs from the Caleb Bell through the wood to a point in the Coed-du cross-course 250 yards south of the house of that name, a great open trench, supposed to have been made during the last century, marking its course all the way. Lastly, 250 yards farther south, runs a string, nearly parallel to the Coed-du Vein, and containing barytes towards its eastern end.

The Cefn-Cilcain Vein was being explored in 1880 by means of a level from the river near Nant-Alyn. The level is driven along a fault running W. 12° S., with a downthrow north, in

shale and black limestone. At 200 yards distance from the road it passes a fault running N. 25° W., on the western side of which the east-and-west vein is shifted 5 yards northwards. The Coed-du cross-course, known here under the name of the Llwyn-traus, crosses the level 100 yards farther west, near the margin of the wood. It runs nearly due north, is nearly vertical, and is filled with smashed limestone and calc-spar. The Coed-du Vein leaves the western side of this fault at first with a direction W. 10° N., as though it had been dragged (or the whole mass of rock bent) southwards by the cross-course, but in a few yards resumes its normal direction of W. 10° S. Shale forms the hanging (eastern) side of the cross-course and lies over a sandstone, more than 30 feet thick, which crops out a little farther south. The same bed of shale that crops out at the mouth of the North Hendre day-level runs on through the limestone in this belt of ground also, passing a little east of Mwyn-bwll, through the Coetia'r-ysgall, midway between the two cross-courses, and, as far as can be judged by the contents of the old hillocks, through the western end of the Coed-du Vein.

The Erw-felin Vein (shaft, 459 feet O.D.; depth, 228 yards) has been explored for a short distance in the Sandy Limestone group on the northern bank of the Alyn, west of Rhydymwyn. It is supposed to be the same as the Vein Susan, but underlies south. This vein was not detected in driving the tunnel-level from the Bryn-celyn Vein to the Old Garreg-boeth Vein (p. 144). The section[1] of the shaft is given below.

Erw-felin Shaft.

	Feet.
Surface-soil	24
Limestone and shale	18
Shale	6
Yellow sandstone	15
Limestone and chert mixed	45
Limestone and shale	51
Sandstone, with a pebble-bed	24
Black sandstone and shale	60
Light sandstone	15
Fine black sandstone and shale	60
White limestone	15
Black limestone with fossils	75
Black shale	9
Grey limestone	78
Blue shale	9
Blue limestone	39
Light shale	½
Limestone	39
Blue shale	1½
Limestone	39
Black limestone and shale	60
	683

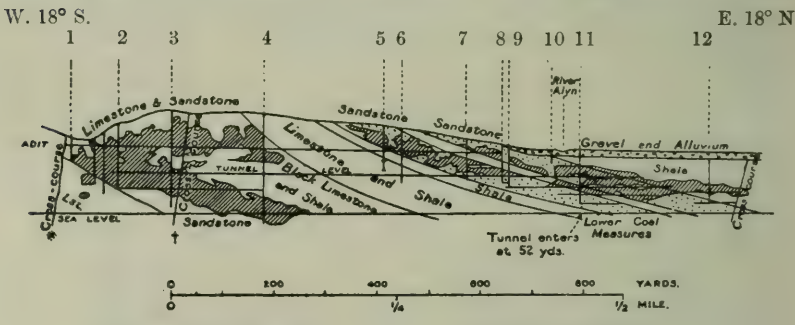
[1] This section was supplied to Mr. Strahan by Mr. John Lloyd, of Rhydymwyn.

5. Rhydymwyn to Gwern-y-mynydd.

The Bryn-celyn Vein, which also underlies south, runs from the river at Nant-Alyn to Rhydymwyn Foundry. Towards the west it was lost under the bed of the river at its intersection with the Nant-Alyn cross-course, and towards the east in Lower Coal Measures, but proved rich in the intermediate ground (Fig. 10, below).

Near the top of the hill the Bryn-celyn cross-course, a powerful downthrow to the west, shifts the vein 40 yards southwards on the eastern side. Near the Bryn-celyn and Taylor's Shafts, situated 30 yards west and 150 yards east of the cross-course respectively, the vein seems to have been worked to a depth of about 220 yards. The old adit-level lies about 75 yards below the surface at the Bryn-celyn Shaft, and runs as far as the Nant-Alyn cross-course ; it comes to daylight some distance south of the Wheel and Whim Shafts. Later it was diverted from near the entrance to a point west of the above-mentioned shaft. It is now dry. The Old Engine Shaft was sunk on the eastern slopes of the valley at Nant-Alyn. Farther east several old whim-shafts have been sunk in the Lower Coal

Fig. 10.—*Section of Bryn-celyn Lode, Rhydymwyn.*



1. Waterwheel Shaft.
2. Old Engine Shaft.
3. Bryn-celyn Shaft.
4. Taylor's Shaft.
5. Dyer's Shaft.
6. Davey's Shaft.
7. Rundee Shaft.
8. Wheel Shaft.
9. Whim Shaft.
10. Bryn (Pryn's) Shaft.
11. Brick (W. Iron) Shaft.
12. E. Iron Shaft.

* The lode has not been found west of this cross-course.
† This cross-course heaves the lode 40 yards southward.

Measures,[1] in a belt of ground separated from the limestone and sandstone surrounding Taylor's Shaft by unproductive strata. A South Lode also was worked in this part of the mine, above the 30-fm. level. The easternmost shaft is situated at the eastern margin of the alluvial flat of the Alyn, and is known as

[1] This is the only case we know of where ore has been got in any quantity from the Lower Coal Measures.

the East Iron Shaft from the fact of its being lined with iron cylinders in the alluvial gravel.

The mine ceased work about the year 1845. The South Halkyn Co. took it up about 1892–3, by which date the Halkyn Drainage Tunnel had reached the vicinity of the West Iron Shaft (Cooke's). A level was driven from the tunnel to Cooke's Shaft and unwatered the mine, whereupon the company drove eastward and westward. They drove a little west of Davey's Shaft and found that this shaft was not continuous but took the form of two sections, divided by a small cylindrical hole. The tunnel is here at 98 yards depth. The Llyn-y-pandy Co. (formed in 1900) then arranged with the Drainage Co. to extend the tunnel, and drove southward from near Davey's Shaft to the Llyn-y-pandy Vein. The South Halkyn Co. next pushed out westward through a barrier of shales and limestones to unwater the western end of the Bryn-celyn Vein, and a run of galena and blende was found in beds of black limestone and shale, 200 to 300 tons being obtained. Between 1903 and 1913 as much as 5,614 tons of galena and 89 tons of blende was raised. The tunnel is 122 yards from the surface at Taylor's Shaft. The lode has not been exploited thoroughly in this part of the mine.

The tunnel extension hit the Llyn-y-pandy Lode at its junction with the Bryn-celyn cross-course in 1901, and drained the west end of the Bryn-celyn Lode.

The water in the Old Garreg-boeth, Bryn-celyn, and Llyn-y-pandy lodes is all in connexion, operations on one lode affecting the other two. In the Government Scheme (p. 25) it was proposed to deepen Davey's Shaft and install two pumps capable of dealing with 1,000 gallons per minute, and to work the deposits lying to the westward, which were expected to yield 100 tons a month.

The Llyn-y-pandy Vein (shaft, 658 feet O.D.; depth, 193 yards) lies about one third of a mile south of Bryn-celyn. It underlies north, and runs from near Hesp-Alyn as far as the Bryn-celyn cross-course, east of which it has never been discovered. The vein has yielded no ore west of the Alyn, but proved so rich on the eastern side of the river that a large sum of money was expended in constructing a water-channel along the cliffs on the eastern bank of the Alyn for more than two miles, in order to work the pumps, etc. by water-power. The Garth Level was commenced in search of the Llyn-y-pandy Vein towards the east.

The following extract[1], taken from an account of a visit to the above two mines in 1798, may be of interest:—

"Another hour brought us to the great object of our day's ramble, Llynypandu Mine, the most considerable lead mining

[1] 'A Second Walk through Wales,' by the Rev. Richard Warner, of Bath, pp. 249–253.

speculation in England. . . . . Llynypandu Mine is the property of John Wilkinson, Esq., the great Ironmaster, who has, with infinite spirit and perseverance, encountered obstacles in bringing it to its present state, that would have exhausted the patience and resolution, as well as the coffers of most other men. With all his exertions, however, he has not been able to render it complete, the mine even now contains so much water, that he has been under the necessity of erecting four vast engines (of Messrs. Boulton and Watt's construction) upon the premises to drain it. . . . . The mountain engine has been lately erected in consequence of a lease of ground, of upwards of a third of a mile in length upon the range of the Llyn-y-Pandu vein, called 'Cefn Kilken,' granted by Earl Grosvenor to Mr. Wilkinson. Many thousands of tons of lead ore are now in stock upon these premises waiting for a market, the war having almost suspended the demand for lead, and lessened the price to nearly one half of what it formerly sold for. The engines also are quiet, and the works at a stand. When the bottom level, intended to communicate all the engines, is finished, great expectations are entertained with respect to the produce of this mine, as it contains one head of solid ore upwards of 6 feet wide, another of 4 feet, and about two feet upon the average for ninety yards in length upon the bottoms. The ore is of two kinds, the one blue, which yields sixteen cwt. of lead per ton, and the other white, which yields thirteen cwt. They are both gotten in the same vein, the white lying in general on the south, and the blue on the north side. When peace shall again have opened a market for lead, these ores are intended to be smelted at works now erecting by Mr. Wilkinson on Buckley Mountain, near the road which leads from Mold to Chester. . . . .

"A little lower down the river, and adjoining to Llyn-y-pandu, is a lead mine called Pen-y-fron [Bryn-celyn], belonging to Mr. Ingleby. This is drained by a steam engine upon the old construction and a water wheel. . . . Independent of these are two other wheels which raise the water from the lower workings to the main level, communicating with the engine. With all this power Mr. Ingleby is scarcely ever able to get to the bottom of his work, except the weather be particularly dry. Were he able to effect this completely, his profits would be immense, since the mine is incalculably rich, there being one vein of solid ore two yards and a half in width, besides several smaller seams. In the few instances where Mr. Ingleby has gotten to the bottoms no less than seventy tons of ore have been raised per week. The blue ore of this mine is not so good a quality as the same species at Llyn-y-pandu, owing to its containing a small portion of black jack. Of white ore Pen-y-fron mine has but a small quantity.

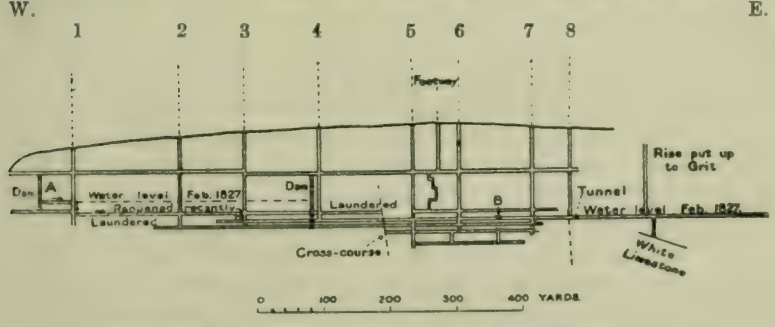
"The great convenience of these works is their compactness. The ore being dug, and the article manufactured, nearly on the

same spot. Smelting houses are in the immediate neighbourhood of the river, for fusing the ore, and casting it into pigs, and about half-a-mile below these premises is a mill worked by a water wheel for rolling the lead into sheets."

Very little appears to have been done on the Llyn-y-pandy Lode after this period. About the years 1827–8 an attempt was made to work the mine deeper, and a shaft—the 'Conqueror of Wales'—was sunk at the eastern end of the mine, and an 80-inch Cornish Engine, with the same ambitious title, was erected; but the water was beyond its capacity, and the works were abandoned. This engine was removed to Cat Hole Mine, and, later, to Minera Mine, where it did about 50 years' good service. A vein of solid ore, 3 feet wide, was reported about the year 1831 or 1832 as occurring at the bottom of the Conqueror of Wales shaft; this has not been got. John Taylor and Sons held that there may be not so much water east of the Bryn-celyn cross-course as west of it. This cross-course terminated the vein as then known.

After the Halkyn Tunnel was driven (1901) the vein was found east of the cross-course (Fig. 11, below). A driving 130 yards in length was made eastward at tunnel-level through grey limestone and shales, but only a little ore was found. A winze, 30 yards deep, was sunk at the end of the level in white limestone, and lumps of good ore found, but there was too much water to allow of it being worked. It should prove good when the sea-level tunnel is driven, or even earlier, if the extensive pumping-scheme (p. 25) is put into operation.

FIG. 11.—*Section of Llyn-y-pandy Mine, Rhydymwyn.*



1. Mountain Shaft.
2. South Shaft.
3. Parrin's Shaft.
4. Watkin's Shaft.
5. Andrew's Shaft.
6. Hodson's Shaft.
7. Conqueror of Wales Shaft.
8. Bryn-celyn cross-course.

A.—A large stream of water issues here.
B.—Launders put in from west to this point.

During the war the tunnel-level was driven westward and launders put in; the object being to ensure the issue of a continuous stream of water (held up in the western part of the

mine) at the Halkyn Tunnel mouth, for industrial purposes. Operations came to an abrupt end about March 1919.

Ore was raised in 1903 (3 tons of galena), and in 1905–1909 (220 tons of galena and 14 of blende), and 2 tons were got from the Mountain Shaft in 1918. In early times the ore won was raised, and probably dressed, at many shafts on the lode. Latterly it was raised at Davey's Shaft on the Bryn-celyn Lode and dressed chiefly at South Halkyn. A little was dressed at the floors south of Rhydymwyn Foundry.

The Rhyd-Alyn or South Llyn-y-pandy Vein is a nearly vertical joint, which was discovered by a cross-cut driven south for about 230 yards from the Llyn-y-pandy Vein. This joint or fissure, filled with spar and galena, was worked eastwards into the Nant-Alyn cross-course, here of great width and packed with smashed-up limestone and calc-spar. A smaller cross-course farther west, perhaps that of Coed-du (Llwyn-traus), shifts the joint 5 yards southwards on its eastern side. The vein has been worked for about 10 chains west of the Llwyn-traus cross-course. The Halkyn Tunnel was carried south-westward for nearly 600 yards from the junction of the Bryn-celyn cross-course with the Llyn-y-pandy Lode, to the Rhyd-Alyn Vein, which it reached in 1903 at the 150-yard level. The point of intersection was on the Nant-Alyn cross-course. The mine was known as the *Rhydalyn* or *South Llyn-y-pandy*. Lead was worked here, and the vein was proved east of the cross-course, which heaves it about 8 yards southwards on this side.

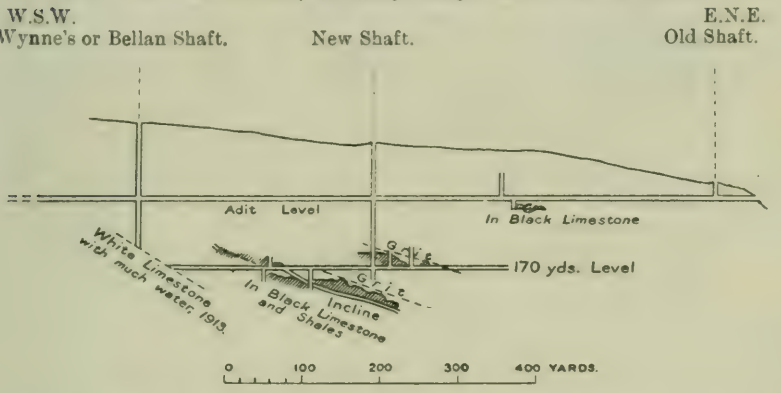
The old Rhydalyn Mine was worked up to 1888. As South Llyn-y-pandy Mine it yielded 4,355 tons of galena between 1889 and 1898, and 1,073 tons between 1904 and 1906. Cerussite was obtained in 1907 (*see* assays, p. 20). The ore from the Rhydalyn joint yielded 7 ounces of silver per ton; that from South Llyn-y-pandy Mine yielded 4·2 to 5·8 ounces. Most of the ore was brought to surface at the mouth of the Rhydalyn adit, to the west, where it was dressed, but a considerable amount was dealt with at Coed-mawr Shaft at the eastern extremity of the mine; and after the main tunnel reached the lode, some was raised at Davey's Shaft (on the Bryn-celyn Lode) and dressed at the South Halkyn floors near the old Rhydymwyn Foundry.

The Pant-y-mwyn Vein (Fig. 12, p. 85) can be traced through nearly the whole breadth of the Limestone and Cefn-y-fedw Sandstone outcrops, and is believed to run on for some distance into the coalfield. Mines on this vein commenced work in 1823 and closed down in 1845, though a little ore was got about 1882. They were taken up again in 1901, when a new shaft was sunk on the site of an old one 30–40 yards deep, and worked to about 1913. Between 1905 and 1909, lead-ore (1,645 tons) and zinc-ore (1,154 tons) were raised.

The vein underlies south and throws the strata down many yards in that direction, the horizontal shift in the outcrops thereby produced amounting to 400 yards. The vein appears

in the old water-channel on the eastern bank of the Alyn near Pen-y-sarn with a width of 21 feet of white calc-spar, and runs thence to near the Crown Inn; but a branch of it, which starts from the river opposite Plâs-yr-esgob, is considered by some the main vein. From the Crown Inn eastwards the vein runs in two, known as the North and South Lodes, both underlying south. The workings in this part seem to have been shallow,

FIG. 12.—*Section of Pant-y-mwyn Mine (East End).*



and much of the ore was obtained in the form known as gravel-ore, that is, as lumps imbedded in Glacial sand and gravel and loosened no doubt from the vein by the weathering away of the walls of limestone. The Nant-Alyn cross-course passes the vein 300 yards east of the Crown Inn and shifts it southwards on the eastern side. The West Flat Rod Shaft[1], near this point, was 120 yards in depth, the end of the Bellan adit-level lying at about 100 yards in depth in it. The Boundary Shaft, about 160 yards farther east, was 200 yards deep; and Taylor's Shaft, at Bryn-côch, vertical to 200 yards, was 256 yards deep, cutting the vein at 140 yards, while the day-level lay here at 104 yards depth. The Bellan adit-level opens onto the Alyn, south-west of Pen-y-garth, at a height of about 390 feet above the sea. The bulk of the ore lay in the limestones below the Hendre sandstones (p. 139 and Figs. 7 and 24).

A second cross-course, passing the vein between the South Shaft and Reed's Shaft, is said to have shifted it 7 feet, the position assigned to this fault lying nearly in the range of the Bryn-celyn cross-course.

A large feeder of water was cut at the bottom of Taylor's Shaft at 238 feet in September 1844, and caused stoppage of the mine owing to expense. At an earlier date feeders cut at shallower depths drained Pant-y-buarth Mine to successively

[1] *See* 'The Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, Fig. 23, p. 187.

lower levels ; hence it is evident that the water in the two mines is in communication. From Reed's Shaft, where the vein occurs at 40 yards, a cross-cut at adit-level was made southward to Mostyn Shaft, where the vein is at 260 yards depth.

An abstract section of the New Shaft, sunk 1901-3, is as follows :—

	Feet.	Inches.
Hillock, surface-soil and gravel	27	3
Black limestones, with hard red gritstone with partings	60	3
White limestone	45	6
White gritstone, with beds of black and grey limestone	44	8
Grey limestones, with thin cherts	69	6
The Lode—blackstone in beds 6 to 12 inches thick	8	0
White grit in beds	20	6
Shale rock	1	3
Grey limestone	41	9
Black limestone, with a 4-inch bed of shale ...	67	10
White grit	19	0
Black limestone	108	0
	513	6

The last-mentioned item rests on white limestone about 12 feet thick, and this on black limestone below the bottom of the shaft. Adit-level is at 70 yards approximately, and at that depth the lode is 7 yards north of the shaft.

A driving was made at the 170-yard level both eastward and westward, and ore worked in black limestone and shales beneath two beds of grit dipping eastward. White limestone, full of water, was found in 1913 beneath the bottom of Bellan Shaft. Ore was got also in black limestone below adit-level at a point 9–10 chains east of the shaft (Fig. 12, p. 85). The ore was raised and dressed at the New Shaft. The galena yielded about 83 per cent. of lead and 4 ounces of silver per ton of ore. The proportion in the older part of the vein amounted to 5 ounces per ton.

There was also a quantity of blende, which was concentrated up to 59 per cent. for the zinc-smelters. The proportion of silver in the Pant-y-mwyn ore reached only 5 ounces per ton.

The Bwlch-y-ddaufryn Vein underlies north, aud runs from Trinity Church, obliquely across the road, into the Nant-Alyn cross-course near Pen-y-sarn, west of which it is not known.

The Pant-y-buarth Vein also underlies north with a hade of about 40 degrees, and throws down the strata a considerable distance in that direction. It can be traced from the Silurian area at Craig (so named on the Old Series map, 79 S.E.), where it shifts the boundary of the Limestone, all across the Lower

Carboniferous rocks, eventually losing itself eastwards in the Cefn-y-fedw Sandstone. In the valley of the Alyn it lies hidden under boulder-clay, but several shafts have been sunk on a nearly vertical string lying south of the main vein, and ranging towards Pen-y-lan. At 300 yards distance from the river this string is crossed by a north-and-south joint (by some supposed to be the Caleb Bell cross-course), the point of intersection being marked by a large swallow-hole at 40 yards depth. A shaft 100 yards northwards passed into a hollow in the joint, filled with tufa and pebbles of Wenlock shale. From Cefn-bychan the main vein runs without interruption to Pant-glâs, its course being easily traced by the fact of its throwing down calcareous sandstone on its northern side against the limestone of its southern side. The principal workings on the vein seem to lie between Park Farm and Pant-glâs, the Engine (Flat Rod) Shaft, 350 yards east of the former, being 120 yards deep, and cutting the vein at 60 yards depth. The easternmost shaft at Pant-glâs was sunk into a mass of broken and confused sandstone, in which no definite vein could be distinguished. A level was opened out at 73 yards.

The Pant-y-buarth Vein seems to be crossed by several north-and-south faults, concerning which, however, little information has been forthcoming. One west of Cefn-bychan, already referred to, crosses the river with several others opposite Bryn-y-castell, and is filled for a width of 10 to 12 feet with coarsely crystallised white calc-spar; another, 100 yards farther west, runs about N. 20° E. At Bryn-hyfryd the Nant-Alyn cross-course cuts through the vein, and at Fron-haul a cross-course, possibly the continuation of that of Bryn-celyn, passes southwards towards Moel-Findeg. This heaves the lode 90 feet southward on the eastern side.

Since the above account was published in 1890 a considerable amount of mining and prospecting work has been undertaken, and additional information has come to light.

The Nant-Alyn cross-course had been driven along for about 70 yards northward from the bottom of Rowland's Shaft, which was reopened by Messrs. Brunner, Mond & Co. (1896–1906) about 20 years ago. A lode—the Cefn-bychan—was intersected at about this distance from the shaft at the 114-yard level, and was driven upon westward for 80 yards until shaly limestone was met. The lode had the same direction of hade as the Pant-y-buarth, and was narrow; it dipped at 52 degrees to 62 degrees. It was also found at the 70-yard level. Some galena and blende were got.

The Pant-y-buarth Mining Co. (1910–1917) started where the previous lessees left off, and drove, at the 114-yard level, 30 yards farther through shaly ground into white limestone, and the lode opened to 4 feet of spar and yellow clay after driving 5 yards. Some 96 tons of ore in lumps were got from this level and a 6-foot winze proved that it continued below. The driving

was carried nearly to Derby Shaft (330 yards west of the Nant-Alyn cross-course) and in 1910 a rise of 23 yards, all in ore-bearing ground, was put up into the old workings from that shaft. They got to the bottom of the shaft and 30 yards west of it, and found that the lode had been extensively worked.

Rowland's Shaft is vertical for 70 yards, and then follows the dip of the cross-course, which dips eastward at 73 degrees, to the 114-yard level. The bottom of the shaft is 25 yards south of the Pant-y-buarth Lode and on the east side of the cross-course. This depth (144 yards) is equivalent to the 88-yard level in the engine-shaft farther east, but this level rises westward. From the 55-yard level Rowland's Shaft communicates eastward with a footway.

As regards the main vein, the Engine Shaft mentioned in the above account is the Flat Rod Shaft; the true engine-shaft being situated about 200 yards farther west. This was originally vertical for 88 yards, where it cuts the vein, and then followed the hade of the lode to 120 yards. Brunner, Mond & Co. carried it down to 144 yards and a considerable amount of blende of good quality, and also some galena, was got.

The 144-yard level is about 500 yards in length. Large solid lumps of galena occurred east of the Flat Rod Shaft in both the 120- and 144-yard levels, and good galena occurred also at the western end of the 144-yard level as a rib averaging 3 inches in thickness. Over the rest of the level the ore was patchy and more blende than galena was found. A little calamine and cerussite occurred at the western end of the 120-yard level. Assays show 54 to 56 per cent. zinc in the blende, 52 per cent. zinc in the calamine and 79–81 per cent. lead in the galena. The zinc was satisfactory for Brunner Mond's zinc-process. Silver varied from 4 to 6 ounces per ton of galena. The mine was closed owing to heavy water.

A lode, termed the Trevathen, with the same hade as the Pant-y-buarth Lode, lies a short distance to the north. It was worked between 1880 and 1884 from Trevathen Shaft, situated about 100 yards west of Park Farm. Two cross-cuts were made to it from the 88-yard level in the Pant-y-buarth Lode. These are 52 yards long, but are now (1919) full of debris. From 20 to 25 tons of dressed galena a month were raised, no blende being found. The percentage of lead was 79 to 80, and silver averaged 4·5 ounces per ton of galena.

A small lode—the Stamp Office Lode—occurs south of the Pant-y-buarth Lode. It was worked long ago, and was afterwards sought by a cross-cut driven southward by the Pant-y-buarth Company, but was not located.

The ore was dressed by Brunner Monds at a plant situated near the Engine Shaft. That got west of the Nant-Alyn cross-course by the later company was lump-ore in clay, and could be treated by hand; the process of dressing being the same as that

employed at the Mount Halkyn Mine, where similar ore occurred. It was carried by tractor to Mold and Bagillt, and sold direct to the smelters.

The *Fron-Fawnog Mine* was worked in the lower of two limestone flats, here about 25 yards apart, the ore following the bedding down a dip-slope of about 1 in 4 eastwards. The flat included two runs of ore, known as the North and the Main Runs, 13 yards apart and ranging about magnetic east-and-west, with a few small strings between.

The 'runs' occupied pipes hollowed out principally in the base of a calcareous sandstone, but partly also in the underlying limestone. The pipes were filled with sand, in which the ore lay as a bed, while the sandstone was soft and honeycombed, a compact roof invariably implying poverty in the run. Though unaccompanied by a vein or fault, such pipes usually follow a small leader of spar in the limestone. They are evidently old underground water-channels, choked up with the insoluble residue of the calcareous sandstone series. The name 'flat' is commonly applied to a bed of limestone in the Sandy Limestone group. Not infrequently there are several flats at different depths in the same mine. At Fawnog two have yielded all the ore, the lower flat in the old mine, and an upper flat, 25 yards higher in the series, in the later workings. The pipes sometimes 'jumped' southwards in their course down the dip-slope, possibly in consequence of slight shifts of the strata by north-and-south faults, and eventually were cut off eastwards by a joint running about N. 12° E., and marked with nearly horizontal slickenside, beyond which little or no ore has been found.

The upper flat lies at a depth of 160 yards at the Engine Shaft, but, rising westwards with the strata, both flats crop out about 100 yards west of the Cefn-y-fedw Sandstone boundary. There they have been worked up to daylight, the whole surface of the ground along the outcrop of each band of limestone having been turned over in search of loose lumps of galena. The confusion of the strata has been increased by the weathering away of the limestones along the outcrop, and the consequent breaking up of the sandstones above them. An inclined plane 300 yards south of the road at Pant-glâs afforded means of access to the lower flat. The ore of Fron-Fawnog yielded about 6 ounces of silver per ton.

Several small trials break the surface of Cefn-mawr, between the Nant-Alyn and the Cat Hole cross-courses, the principal vein being the Deborah, which runs nearly south-west near Cefn-mawr Farm and hades southward at a steep angle. Some work was done at the Cefn-mawr Shaft in the years 1900 and 1901. The shaft is vertical for about 67 feet to the lode, and then follows it in its inclination. Levels have been driven at 50, 66, 70 and 76 yards depth. A more powerful vein crosses the Cefn-y-fedw Sandstone 100 yards south of Hafod, and has

been followed in a direction a little north of west for a short distance through the 'flat-measures' (the Sandy Limestone group). The Deborah Shaft, sunk near the line of the fault, and at a point 300 yards west-south-west of Hafod, supplies the following notes. The chert, which here forms the middle division of the Cefn-y-fedw Sandstone, extends to 12 yards depth, and rests upon sandstone with quartz-pebbles. The sandstone, at 52 yards from the surface, contains a band of limestone, which is probably the Little Flat of Fron-haul, and at 87 yards depth rests upon the upper 'flat-limestone.' Explorations were made at this depth along the junction of the sandstone and limestone, a level driven northwards showing the surface of the limestone to be unevenly eroded, or eaten into, by percolating water, while a cross-cut driven 18 yards southwards encountered a fault running W. 5° N. and underlying north. North of the fault the strata dip eastwards at 4 inches to the yard, but south of it dip north-eastwards at 8 inches to the yard. The shift effected by the fault on the outcrops amounts to about 300 yards.

The *Gwern-y-mynydd* and *Cat Hole Mines* (Pl. III) are situated on a powerful fault that ranges a little south of east and throws the strata down about 110 yards to the north, thus shifting the outcrops about 600 yards. At its western end the vein runs into the Nant-Alyn cross-course, the intersection of the two giving rise to a large cavern filled with white sand, but it cannot be traced farther under the Glacial gravel of Pwll-y-blawd. Eastwards from Glan-Alyn it can be followed by a line of old shafts to Cat Hole, crossing the road at Parc-Arthur Farm, where it was worked so near the surface as to cause the road to fall in. Near this point it throws off a string on the south, known as Pilkington's Vein, which, with some others, has been worked through the wood on the northern side of the road as far as the river. The adit-level runs from the Alyn to Francis Engine Shaft (east of Parc-Arthur Farm), which it enters at a depth of about 50 yards. This shaft is 200 yards deep and cuts the vein at 180 yards; the Old Engine Shaft near Cefn-mawr Hall, 140 yards deep, reaches the vein at 100 yards. A run of ore extended from near the surface between 200 and 300 yards west of the Engine Shaft to a depth of about 200 yards at the Francis Shaft, sloping down eastwards with the dip of the strata (Pl. III).

The Cat Hole cross-course intersects the vein close to Parc-Arthur Farm, disorders the hanging and hading walls for a short distance, and heaves it southward on the east side. Near the point of intersection several trunks of trees resembling those of Pant-y-ffrith (p. 68) occurred.[1]

---

[1] 'The Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, p. 190.

Between the Cat Hole Vein and Cefn-mawr Hall a fissure in the limestone, running nearly parallel to the main vein, lies open to a depth of 30 or 40 yards ; at the time of the falling in of the trees the Cat Hole Vein seems to have been in a similarly empty condition, but at what date this occurred we have no evidence to show.

At its eastern end the Cat Hole Vein runs through the Gwern-y-mynydd Mine. It follows the road closely from Parc-Arthur to a point 200 yards east of the Rainbow Inn, where it divides into the Fron-isaf Vein running a little south of east, and a number of strings branching off a little north of east. The Fron-isaf Vein was worked in the wood 200 yards north of Fron-isaf, and yielded ore in the chert, but not in the 'flat-measures.' A shaft just above the wood reached the vein at 60 yards and a flat (probably the Little Flat) at 80 yards, over which lay six or eight yards of shale. The strings farther north were numerous in the field above the wood, and yielded ore in the chert. The workings in these were drained by a day-level, the mouth of which lies 300 yards south-west of the old County Gaol. The level traverses shales and sandstones, and passes two or more north-and-south faults, in one of which green and slightly phosphorescent grains of copper-ore occurred. Nearly under the road some strong joints, perhaps the strings referred to, range about west-south-west along the level, while 112 yards west of the cross-cut to the Old Engine Shaft, limestone rises into the level, sinking again out of sight in about 40 yards. At 161 yards from the cross-cut it reappears for a distance of 6 or 7 yards, the level keeping nearly along the strike of the beds, so as to touch the limestone in the crest of each fold in the strata. The limestone, which is coarsely crystalline and lies next below a yellow sandstone, seems to be the Little Flat of Fron-haul. On the northern side of the road, at 350 and 250 yards respectively west of the Turnpike, the Tom-and-Jerry and the Treasury shafts have been sunk in the Cefn-y-fedw Sandstone ; the latter passed through hard rocky shale with black and white sandstone to a depth of 60 yards, with a 9-inch seam of coal at 30 yards, and then entered cherty sandstone. At 60 yards depth a cross-cut was driven to meet the day-level from Fron-isaf, and a continuation of the level was carried westwards for about 360 yards, passing the Tom-and-Jerry Shaft at about 70 yards depth.

The Tom-and-Jerry Shaft was sunk to a depth of 140 yards to intersect a run of ore that followed the top flat on the northern side of the vein, and came to near the surface 300 yards west of the Rainbow Inn. The day-level was driven as far as a shaft 150 yards north-west of the Rainbow Inn. It will be observed that the vein described above bore lead at three horizons, firstly, and most abundantly, in the massive limestones that form the hill of Cefn-mawr ; secondly, in the overlying limestones and sandstones that form the 'flat-measures' of the

miners; thirdly, in the chert and cherty sandstone that form the middle portion of the Cefn-y-fedw Sandstone. The proportion of silver in the ore reached only about 5 ounces per ton.

The galena from the flat-measures contained only 2 to 4 ounces of silver per ton; it makes excellent 'potter's ore.' These measures contain no blende. Some of the blende from the main lode assayed 58 per cent. of zinc. Small quantities of calamine with 61 per cent. zinc were found at the western end of the Cat Hole Mine. During the last years all the ores gotten at the Cat Hole, Deborah and Gwern-y-mynydd Mines were carted to Pant-y-buarth to be dressed. At Gwern-y-mynydd about 48 tons of lead-ore were got between 1900 and 1904.

About the year 1884 the lode was cut at the Treasury Engine Shaft and driven upon for a short distance at a depth of 166 yards. A rib of galena, 2 inches wide, was found on the footwall, which was Cefn-y-fedw Sandstone, the hanging-wall being hard black shale.

Between 1896 and 1903, Messrs. Brunner, Mond & Co. carried out further work under the supervision of Capt. J. Roberts. The Rainbow Shaft was deepened from adit-level to below the 170-yard level, and Treasury No. 2 Shaft, which was shallow, was deepened to the 200-yard level, and a powerful Cornish engine set up. The day-level of the Gwern-y-mynydd Mine was driven westward (Pl. III) to the Cat Hole (Francis Engine) Shaft, to unwater part of the Cat Hole Mine. It was driven in the lode a part of the way only, as it was diverted through soft ground (said to be in synclinal form) to take a straight course to the Cat Hole Shaft, which at adit-depth is a considerable distance north of the lode. Near the Francis Shaft, flats in sandstone, on the south side of the vein, were worked from an incline rising from the day-adit, which is here at 86 yards depth. This adit is 36 yards below the level of the River Alyn. At a later date, from the Treasury Shaft, the day-level shown in No. 1 Shaft (Pl. III) was carried through to the Treasury No. 2 Shaft.

6. Gwern-y-mynydd to Maes-y-safn.

Several shafts have been sunk through the Cefn-y-fedw Sandstone of Bryn-gwyn into the top flat, one of them, 100 yards south-east of Fron-uchaf, proving this bed (the limestone worked in the quarries close by) to be 18 yards thick. The *Fron-haul Mine* is situated on a vein 250 yards south of, but parallel to, the Fron-isaf Vein. The Little Flat, reached at a depth of 50 yards in the Engine Shaft, varies from 1 to 3 feet in thickness, while a coal-seam lies at about 8 yards depth, and appears also in the day-level. The Whim Shaft west of the Engine Shaft cuts the vein at 60 yards, and a limestone, which is not shifted by the vein, at 80 yards depth. The limestone, coarsely crystalline in texture, lies below 7 or 8

yards of shale, and therefore corresponds rather with the Little Flat than with the top flat as seen in the Bryn-gwyn quarries. The greater depth to it in this shaft seems to indicate the existence of a fault, not improbably running through the Engine Shaft, the strata in which are nearly vertical. Such a fault would explain also a feature that runs in a north-north-west direction from Pentre-bâch, and of which the steep bank of Fron-haul and Fron-isaf forms part. The Little Flat has been found also at 20 yards depth in a shaft 350 yards south-west of Fron-haul, on which evidence its outcrop is indicated on the map (79 S.E.). The last ore raised was got in 1888.

The Coed-Cynric Vein underlies north and runs through the fireclay-pit near Colomendy. The lead-ore in the pit occurred in the form of lumps of carbonate, formed by the decomposition of lumps of galena. The 112-yard level below the pit passed through swallow-holes filled with sand and clay, but in the 66-yard level these materials occurred in abundance. The Engine Shaft touches the vein at 112 yards depth. Eastwards the vein is known no farther than the road past Aberdine, though a whim-shaft has been sunk by the side of the Mold Road at London to a depth of 80 yards, chiefly through black limestone and shale, with a good deal of fluorspar.

The *East Maes-y-safn* or *Glyndwr Mine* lies nearly on the line that the Coed-Cynric Vein might be supposed to take, but the workings have disclosed no vein, though ore has been raised from the flat-measures. The top flat has been followed down its dip eastwards in a succession of shafts for about 550 yards beyond the boundary of the Cefn-y-fedw Sandstone. The older shafts, near this boundary, reached the top flat at 13 and 30 yards; Pellew's Shaft, 100 yards west of the road, at 90 yards; the Old or North-West Shaft, 30 yards east of the road, at 100 yards; the flat then dips rapidly to a depth of 144 yards, but rises slightly again eastwards to the Engine Shaft (887 feet O.D. and 144 yards deep), 200 yards east of the road, the mine thus occupying a gentle syncline in the strata. The Engine Shaft passed through the following beds:—

East Maes-y-safn Shaft.

	Feet.
Chert, etc.	345
Shale	6
Chert	9
Sand	9
Shale, thinning out westwards	6
Grit	12 to 15
Shale, clay, and sand mixed, forming the 'hanging' of (or the bed overlying) the flat	45
	435

The strata dip westwards at a gentle angle in the top of the shaft, but steeply at 100 yards depth, while they lie nearly flat

in the bottom of the shaft. At 50 yards west of the shaft the flat dips eastward.[1]

In 1891 high-water mark stood at 123 yards depth, and low-water mark at nearly 128 yards. The proposed tunnel of the Llanarmon District Mines Drainage Co. from the east (p. 28) would be 33 yards below the bottom of the shaft. The last output of ore was 5·5 tons of galena in 1891.

Between this mine and Bryn-gwyn two runs of ore have been worked in the top flat. The one known as the Mount Pleasant run starts from the road 220 yards east of the Owen Glyndwr Inn, and runs for about 500 yards towards Fron-haul, nearly, but not quite, along a fault with a downthrow of 18 yards to the north-west; the other, or the Bryn-gwyn run, starts 50 yards north-west of that inn, and runs 200 yards to Bryn-gwyn Farm, where it lies at 80 yards depth. A shaft, 150 yards north-east of the farm, met the flat at 110 yards depth, and showed the strata to dip westwards, as at East Maes-y-safn. Both the Mount Pleasant and Bryn-gwyn runs terminated in a cross-course that passes under Bryn-gwyn Farm, a little west of north, but which is stated not to shift the strata, and is probably of little importance. The top flat limestone has so far perished along the Mount Pleasant run as to occur as boulders only, not as a solid bed.

South-west of East Maes-y-safn lies the *Jamaica Mine*, in which a rich flat was worked. The limestones here have completely perished along the outcrop, and the Cefn-y-fedw Sandstone and the sandstones of the flat-measures have fallen together. No vein was ever discovered,[2] but drivings down the dip-slope and along the horizon of the top flat disclosed rich bunches and runs of ore as far as a depth of 70 yards, below which the ground became barren. The flat crops out near the house called America, but from the reason stated no limestone appears, and the Cefn-y-fedw Sandstone reposes on sand for a distance of about a quarter of a mile. The productive ground, however, extends only about 300 yards west of that house. Much of the ore of this mine occurred in the form of carbonate of lead.

The *Maes-y-safn Mine* (Fig. 13, p. 95), with the exception of Talargoch, attained a greater depth than any other in Flintshire,

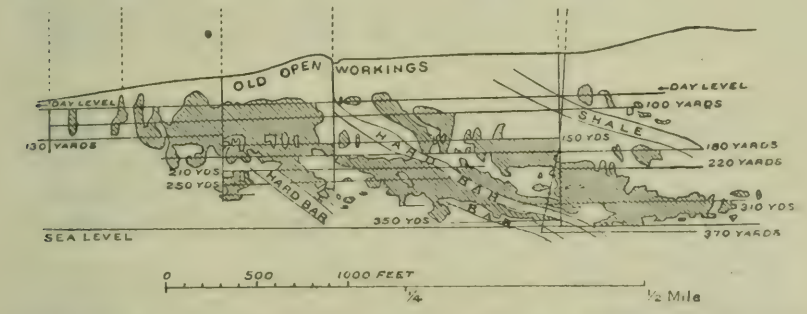
[1] The information regarding this shaft was supplied to Mr. Strahan by Mr. Thomas Miners.

[2] 'Geology of Flint, Mold, and Ruthin,' p. 193. But an old plan (R. 51) of Jamaica Mine, deposited in the Home Office and dated 1849, shows a section of a vein hading southward and shooting eastward. We are informed on good authority that the names of the three shafts indicated on the plan, namely Lowe's, Francis's (134 yards to the east), and Dyer's (86 yards still farther east), correspond with those of people associated with the Jamaica Mine when the flat was worked. It is possible, therefore, that the flat was connected in some way with this vein, which was worked from levels at 15, 28, 35 and 43 fathoms, the greatest amount of ore being got between Francis's and Dyer's Shafts.

namely, 390 yards.[1] The vein runs nearly parallel to the Gwern-y-mynydd Vein, and, like it, throws the strata down to the north. It traverses the whole Limestone outcrop, but cannot be traced in the Wenlock Shale on the west, or far into the Cefn-y-fedw Sandstone on the east. It was drained by a water-wheel and day-level into the Alyn below Llanferres, the level running eastwards to a point about 200 yards beyond the Grosvenor Shaft, or 1,400 yards in all.

The position of the vein at the surface can be traced with ease, partly by old surface-workings, partly by its effect in bringing face to face strata of different character. The vein underlies at a low angle, with the consequence that its intersection with the undulating surface of the ground forms a

FIG. 13.—*Section of Maes-y-safn Lode.*



somewhat sinuous line when drawn upon a map, but the day-level, driven for all its length in the vein, keeps a nearly straight course. The underlie of the vein at different points is given by the following figures: at No. 2 Shaft, 66 in 100; at No. 3, 112 in 100; at the Grosvenor Shaft, 110 in 100. No. 1 Shaft, situated 300 yards from the intersection of the vein and the River Alyn, was sunk to 150 yards, passing through the vein at 130 yards; No. 2 Shaft, 600 yards from the same point, was 270 yards deep and intersected the vein at 54 yards; No. 3 Shaft, 770 yards from the same point, met the vein at 100 yards and was continued down the incline of the vein to a depth of 310 yards; the Grosvenor Shaft, situated 1,180 yards from the same point and at the foot of Moel-Findeg, entered the vein at 180 yards and was sunk in it to 390 yards from the surface; No. 4 Shaft, lying 100 yards south of the Grosvenor Shaft, caught the vein at 70 yards depth, from which the underlie, as given above for this point, has been calculated. The workings extended 360 yards east of the Grosvenor Shaft at 310 yards

[1] The greatest depth reached in the Talargoch Mine was about 400 yards.

depth, but not so far at a less depth. The 310-yard level probably ended in, or close to, the Cat Hole cross-course, which traverses Moel-Findeg, throwing the strata down westwards. The vein continues its course eastwards, nearly along the road, and a few shafts have been sunk upon it in the Cefn-y-fedw Sandstone, but without any noteworthy result.

The Maes-y-safn Vein proved to be richest in the same beds that contained the lower of the two runs of ore in the Cat Hole Vein, namely, the massive limestones of Cefn-mawr. In working eastwards the ore became abundant between Shafts Nos. 1 and 2 and continued so to about 100 yards east of Shaft No. 3, the old surface-workings showing that the vein was productive here up to daylight. From this tract the ore-body ran downwards towards the east at an angle corresponding to the dip of the strata (about 1 in $1\frac{1}{2}$). The deepest workings, however, near the Grosvenor Shaft, reached the upper part only of this productive belt, for the lower part should occur at a depth of 400 to 600 yards in that part of the mine. The increasing cost of pumping, combined probably with decreasing richness in the lode, precluded any further deepening of the mine.

Explorations, supervised by Capt. J. Roberts, were carried out by Messrs. Brunner, Mond & Co. between 1896 and 1903. Between October 1899 and December 1901 a driving was made eastward beneath Moel-Findeg at adit-level from south-east of the Grosvenor Shaft to a shaft about 290 yards west of Cefn-hîr, a total distance of about 500 yards.

The driving reached the Cefn-hîr Shaft at about 116 yards depth and confirmed the synclinal structure of Moel-Findeg as determined previously by surface-mapping. The two limestone flats were proved, but no ore found in them, and the central part of the driving passed through the Cefn-y-fedw Sandstone Series. The sequence of beds above the shale occurring at adit-level near the Grosvenor Shaft (Fig. 13) was as follows:—

Cefn-y-fedw Sandstone (so-called Millstone Grit).
Top Flat (limestone or limestone boulders, crushed chert and clay).
Sandstone.
Lower Flat.
Dark limestone and shales.
Sandstone.
Dark Limestone.
White Limestone.

The Cefn-hîr Shaft (40 yards deep) was sunk to a total depth of 164 yards, the lower 20 yards being in coarse white limestone, beneath the darker limestones. From near the bottom of the shaft a cross-cut, about due south, was driven at the 155-yard level for a considerable distance; at 25 yards a lode was intersected. This was 2 feet 6 inches wide, and composed of calc-spar and soft brown shale; it was driven upon eastward for about 66 yards, but no ore was found,

though the strata were proved to be turning over from a westward to an eastward dip (S.S.W. at 62° to N.N.W. at 72°). The 155-yard cross-cut also was driven northward without success and was abandoned in December 1905. About 54 tons of ore were got in the whole period.

At the Lisburn Shaft, 345 yards south-west of Cefn-hîr, a cross-cut at 90 yards depth was run south-south-westward for a distance of 330 yards to prove the Maes-y-safn Vein or Fault, but nothing was found, although the shaft is only 100 yards from the supposed surface-position of the fault, which hades northward. On the north-east side of the shaft, at the 116-yard level, about 4 tons of blende, occurring as discs, with a little galena, were found in dark shale in sandstone near the base of the Cefn-y-fedw Sandstone. The bearing of the lode was about W. 23° S.

7. Maes-y-safn to Llandegla.

The next veins to be described lie about two thirds of a mile south of the Maes-y-safn Vein, running nearly parallel to it and like it throwing the beds down to the north. Towards the east a well-defined fault shifts the Cefn-y-fedw Sandstone base as much as 700 yards (or vertically about 114 yards), while towards the west we find a dislocation of the Limestone base at Llanferres, nearly in the same line. Between these two points several minor veins and faults appear, none of much importance. Commencing in the west we trace the Llanferres Fault through a small hollow (filled with Glacial sand and gravel) in the Limestone east of the Alyn. Thence it runs through the *Waen-lâs Mine*, east of which in the wood it has been cut clean out to the surface; about 100 yards north of it, a line of small trial-shafts marks the course of the Waen-lâs-bâch Vein, while 150 yards south of it lie old workings on the Garreg-y-cochion Vein. Nearly along the eastern margin of the wood, a cross-course cuts through these three veins, and seems to shift each a few yards southwards. The Waen-lâs Vein runs under the northern margin of the little marshy flat of Pant-du, and, under the name of the Pant-du Vein, was worked there in a shaft 140 yards deep (60 yards to reach the vein and 80 yards in it). The Waen-lâs adit-level is 315 feet below the top of Shone's Shaft.

The Garreg-y-cochion Vein crosses the marsh and has been worked open to daylight, under the name of the Pentre-hobin Vein, on the southern side of the road. A third vein, known as the Goodwin, also traverses the hollow, and has been worked open across the hill on the northern side of the road. The Pentre-hobin and the Goodwin veins join at the cross-roads, and have been worked to a depth of about 120 yards. From this point there is no further working on the vein till we reach Nerquis Mountain, where the East Pant-du Shaft, sunk on the line of fault, reaches the top flat at 114 yards depth. The shaft

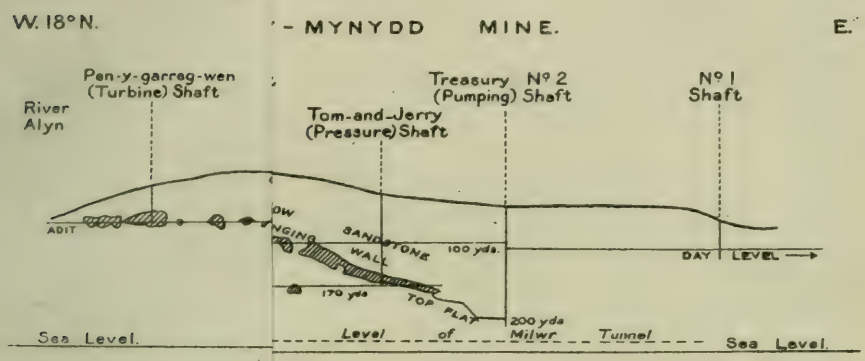
goes down to the 150-yard level, which is a little above adit-level. The vein hades at 35 degrees, and stopings, down to the 110-yard level, are shown on the old plans. No. 2 Shaft is vertical for 95 yards, whilst No. 1 Shaft, farther west, is 50 yards deep. The last ore was raised about the year 1888. It will be observed that the surface-workings in this group of veins lie in the same zone of limestone as those on the Maes-y-safn Vein, and indicate a run of ore in a corresponding position. The ore, however, in this case was distributed among a number of minor veins, instead of being concentrated along one fissure.

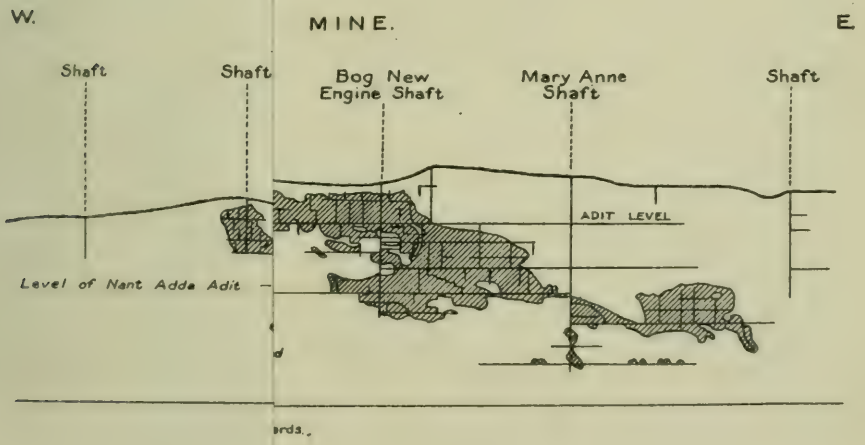
The Belgrave Vein, lying half a mile south of the Waen-lâs, runs parallel to it and also throws the strata down (and accordingly underlies) northwards. It forms a single and nearly straight line of fracture from the Alyn to the Cefn-y-fedw Sandstone at Pant-terfyn, where it is lost in thick sandstones. An old level marks the point at which it issues in the valley of the Alyn ; thence it runs 350 yards to a cross-course, on the eastern side of which it seems to be shifted southwards. Reappearing at Bryn-yr-orsedd, it may be followed across terraces of bare limestone to Pwll-y-wrâch, a pot-hole filled with sand, and thence by the Belgrave Mine (Pl. III) to Gors, near which it passes through, or near, three peat-filled hollows in the Limestone. It seems to have been mined chiefly at Bryn-yr-orsedd (by shafts and levels driven into the hill-side), and at the *Belgrave Mine*; but east of this it seems to have been left almost untouched. It was last worked in 1882. On its northern side, and at a distance of 300 yards from it, runs Taylor's Vein, a small lode, underlying north, on which two or three trial-shafts have been sunk.

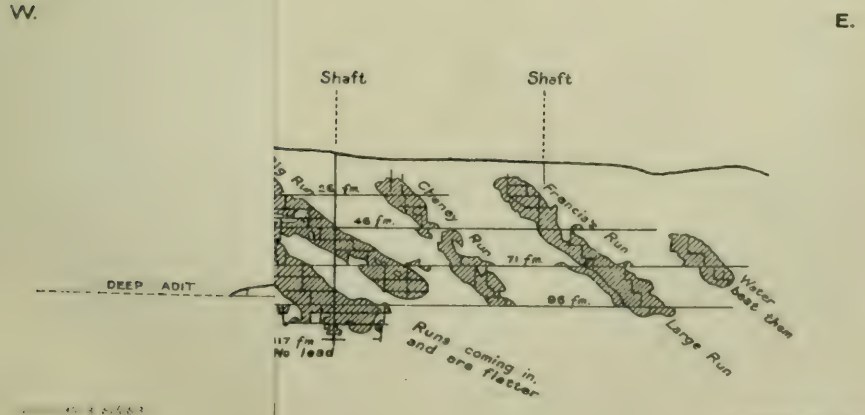
The Blaen-y-nant Vein, a fault with a downthrow north, runs parallel to those described above, at a distance of about 650 yards from the Belgrave Vein. It can be readily traced up from the valley of the Alyn to the cross-course mentioned above, by which it undergoes a shift similar to that of the Belgrave Vein. Thence it runs to Erryrys, passing along the southern margin of the peaty hollow in that village, and eventually becoming lost in the Sandy Limestone group (flat-measures) farther east. Half a mile west of Erryrys it throws off the Craig-y-bryniau Vein on the north, the course of which is marked for about half a mile by a line of old shafts. A small string on the southern side of the vein has been worked at Pwll-heli. There are two shafts on the Blaen-y-nant Vein in or near Erryrys, and one 700 yards farther west, but little work seems to have been done in any part of the vein.

The Westminster Lode shows a similar character, both in direction and throw, to the Blaen-y-nant Vein, and lies about 600 yards south of it. It starts in the eastern side of the valley of the Alyn and runs in two branches to the cross-course previously mentioned, the more northern of the two being visible as a rib of spar 3 feet broad. This has been worked in a level

LONGITUD[INAL SECTION] ER, BOG, & BELGRAVE MINES.

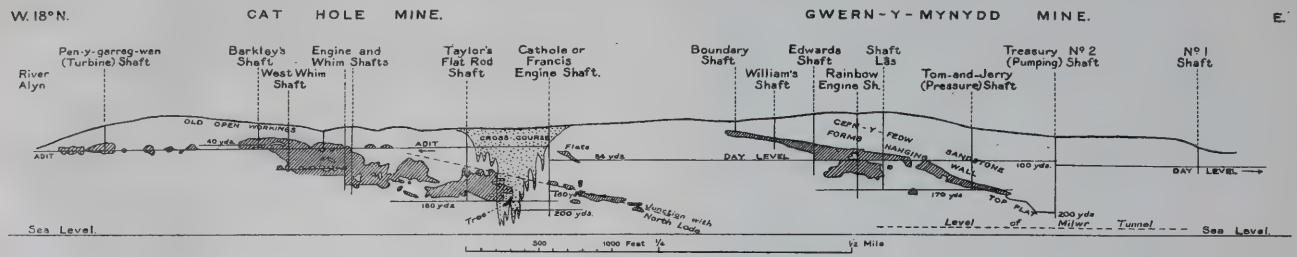


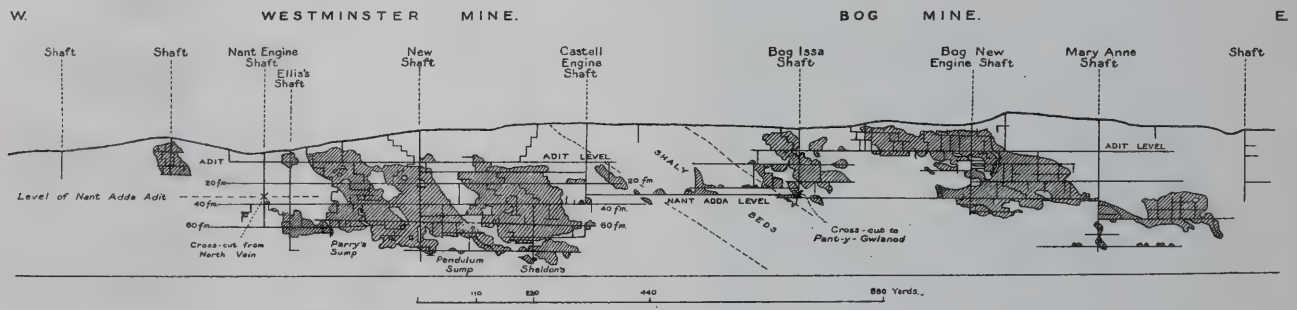


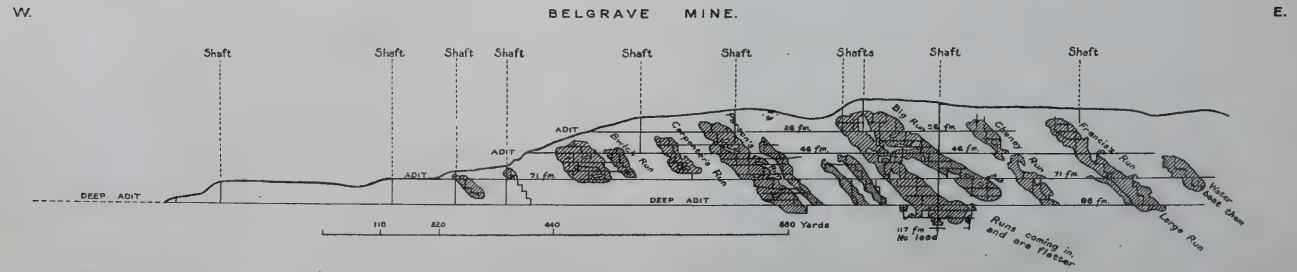


Malby & Sons Lith.

LONGITUDINAL SECTIONS OF THE CAT HOLE, GWERN-Y-MYNYDD, WESTMINSTER, BOG, & BELGRAVE MINES.







Malby & Sons Lith.

and in open trenches, and is known as the Bryn-haidd Vein. East of the cross-course the two branches continue their course, running at first about 40 yards apart. The more southern of the two, known as the Pant-y-gwlanod, keeps a nearly straight course; but the northern branch, or Westminster Lode, makes a bend northwards till it reaches a distance of about 240 yards from the southern branch, in which relative positions the two traverse the rest of the Limestone-area. The Westminster Lode has been worked extensively in the old *Nant Mine* (Pl. III), and to a smaller extent in the *Bog Mines* (Bog-Issa Shaft), near the outcrop of a band of black limestone ('bastard Aberdo' limestone), runs of ore occurring both above and below this band. At a later date it was worked, up to about the year 1868, in higher beds of limestone to a greater extent from Bog New Engine Shaft and Mary Anne Shaft, farther eastward. Thence eastwards the vein has been explored at intervals through the flat-measures as far as the *Llanarmon Mine*, on the Cefn-y-fedw Sandstone of Mynydd-du, the section [1] of which is as follows:—

Engine Shaft, Llanarmon Mine.

	Feet.
Strata sunk through by a previous company	138
Yellow and brown coarse sandstone..	85
Yellow and white sand with a little chert	3
'Pudding-bed' (sandstone with pebbles of white quartzite)	5
White sandstone	21
'Horse-clay' (stiff reddish clay)	7
'Blacking' and dark-coloured chert	4
Light-coloured chert	15
'Tuftan'	2
Soft white sand	13
Hard white sandstone	24
Soft red sand	28
Stiff reddish-yellow clay	1
Tumblers (loose blocks) of limestone in thin layers with thin layers of soft brown shale between	8
Dark thin-bedded limestone	42
	396

Near Waen-dyllog the vein seems to split, for there are indications of a fault running through Maes-y-droell, and south of the Pen-y-foel sand-pit. In the Pant-y-gwlanod Vein a run of ore commenced near the hamlet of that name, and below the black limestone alluded to above. To the east of that band the vein has been worked up to the surface, but has not been mined farther east. The vein contained a quantity of barytes, which interfered with the dressing of the ore. The late Duke of Westminster's agent is reported to have stated that about £3,000,000 worth of ore had been got from the Pant Lode and the Bog Mines. These veins all cease to be recognisable at the surface on entering the area of the Cefn-y-fedw Sandstone.

[1] Supplied by Mr. J. A. Ede to Mr. Strahan.

Between 1890 and 1900 some explorations, supervised by Capt. M. Francis of Halkyn, were conducted on these lodes. The driving of the Nant-Adda adit from the River Alyn was resumed in the northern branch of the Westminster Lode, but the latter was found to be unproductive. A cross-cut was then made through country-rock southward to the Westminster (Nant) Lode at the Nant Engine Shaft (1,000 yards west of Bog-Issa Shaft, Pl. III), and the Nant Mine drained to adit-level from end to end. A driving was then carried through from the eastern (Castell) Engine Shaft in that mine to the Bog-Issa Shaft of the Bog Mines, which were drained to adit-level. This driving was 400 yards in length, from shaft to shaft, in a lode 12 feet wide in places, consisting of spar, limestone and shale, and limestone (probably silicious), the country-rock being dark limestones and shales. A few little runs of ore were found and stoped. Between 1894 and 1900 about 915 tons of zinc-ore and 37 tons of lead-ore were obtained.

At Bog-Issa Shaft there is a cross-cut of several feet to the lode, which at this depth lies north of the shaft. To the south of the shaft a lode, or a branch of the main lode, was found at a distance of several feet; it contained 18 inches of spar with an eye of lead in the roof, and was followed for a short distance. It is not known whether the old miners worked this lode, which might prove productive if followed eastward.

It was intended to prove the Bog Lode in the sandy measures farther east, and also to cross-cut both north and south to intersect the other Llanarmon District lodes in the eastern belt, but when a cross-cut had been made from the Bog-Issa Shaft to the Pant-y-gwlanod Vein, which it intersected unfortunately at an unproductive point (100 yards east of the point to which it had been worked previously) in dark limestone, no money was left for further exploration. The last returns of ore from this vein were made in 1886 and amounted to 5 tons A compressor plant and rock-drills, in a condition ready for work, remain at the Bog-Issa Shaft.

The Tan-y-graig Lode crosses the southern margin of the Old Series One-inch map 79 S.E. It has been worked for a short distance by an open trench, and towards its eastern end by an engine-shaft; it runs parallel to the last-described, but can be followed for about 400 yards only, and not so far east as the most productive zones of the Limestone. It is worth noting that the limestone forming the hanging side of the vein is bent down towards the lode for a few feet, while that in the hading is bent up towards it, *i.e.*, in both cases in the opposite direction to what is usual in a normal fault. Some large open spaces and old washing-floors found in the underground workings in the vein seem to indicate that the ore was washed by the 'old men' before being raised to the surface, where water is scarce. A quarry about 400 yards east-south-east of the *Tan-y-graig Mine* shows fluorspar in a north-and-south joint.

South of the Tan-y-graig Vein, and distant from it 180 yards and 470 yards respectively, lie the Creigiawg Lode and the Maes-y-pwll Lode, with a lode running east-and-west obliquely from one to the other, known as the Vein Ganol. The two first-named have the south-easterly direction and northerly underlie common to all the veins in the tract of Limestone south of Maes-y-safn, but the Vein Ganol underlies south. The Creigiawg Lode runs from Plâs-du as far as the outcrop of the black limestone spoken of above, where an Engine Shaft has been sunk to a depth of 100 yards. The last ore was raised in 1884. The Maes-y-pwll Lode has been trenched across the limestone hill north-east of Llanarmon Mill, and then appears in the bend in the high-road 500 yards east of the mill, where a swallow-hole in the vein serves for the reception of the drainage off the road. The Vein Ganol joins it near the black limestone outcrop, and has been worked both in open trenches and at a depth of 60 yards. A few yards farther east lies the Engine Shaft on the Maes-y-pwll Vein, which is 130 yards deep, and passed through 50 yards of black limestone ('bastard Aberdo'). Ore occurs in two runs in these veins, the one above and the other below the black limestone, as in the Westminster Lode. The Maes-y-pwll Lode runs on through the Sandy Limestone group and into the Cefn-y-fedw Sandstone near the north end of Llyn-Cyfynwy, where it disappears. Barytes occurs at that spot, but more probably in connexion with some north-and-south faults than with the vein.

It is possible that the shafts of the old 'Lead Mine' on the grit-moorland two-thirds of a mile north of Maes-Maelor Farm are sunk on the south-eastward continuation, real or supposed, of this lode, which, however, cannot be traced at the surface. The venture does not appear to have been successful.

A fault-vein with spar, occurring south of the Maes-y-pwll Lode, runs from Creigiog-isaf in a south-easterly direction. Its course is shifted to the south by an oblique fault south-west of Alltgymbyd, after which it resumes its original course, and is accompanied by a parallel fault about 100 yards to the south. The outcrops of the veins are marked by old shafts and open-cast workings for lead, which seem to have been moderately successful.

Similarly the course of the Bôd-Idris Fault farther south, which underlies north, is marked by shallow trenches and trial-shafts dug in the shattered spar-filled rock of the fissure. *Bôd-Idris Mine* produced about 70 tons of lead-ore between 1876 and 1880, when it was last in work. This is the most southerly of the mines north of the Llanelidan and Bala Faults that appear to have been worked with any success, although a shaft was sunk and a level driven in the Rhôs-ddigre Fault at Rhôs-ddigre, and other trials were made along its outcrop.

8. Llandegla to Minera.

Along the Bala and Llanelidan Faults, from the Llandegla district to the Minera district, ores appear to be generally absent. Several trials, however, have been made for ore on some slight indications of galena with calc-spar, such as occur in the face of the small cliff of faulted sandy limestone between Pen-lan and Hafod-dafolog, in the Llanelidan–Bala fault-valley south of Moel-garegog.

The Cefn-y-fedw Sandstone, again, on the north side of this large fracture, has been very thoroughly explored north of the Minera Mines in the hope that the Minera veins would be found on that side. Little success has attended these efforts. The Bala–Llanelidan Fault, in fact, is an older line of fracture than the Minera fault-belt and was moving at more than one period, and the relationships of the two are such that we should not expect to find the mineral veins repeated upon the north side of this great master-fault (p. 13).

CHAPTER IV.

OLD MINES AND MINES RECENTLY ABANDONED.

Area 3.—The Bala Fault to Llanymynech.

GEOLOGY.

In this area the same geological sequence obtains as in the area north of the Bala Fault (pp. 36—38), though certain changes appear as one travels from north to south.

The Carboniferous Basement-Beds are fully developed in the trough of the Dee Valley syncline, beneath the Eglwyseg escarpment north of Llangollen, but northward the Basement-Beds first, and then the different members of the Lower Grey and Brown Limestone, and the lower part of the White Limestone, are in turn overlapped by the succeeding members of the Limestone series. Thus near Minera the upper part of the White Limestone, with a pebbly base, rests directly upon the Lower Palaeozoic rocks. Similarly, towards the south, the Upper Grey Limestone south of Fron-Cysyllte comes to rest upon the Lower Palaeozoic rocks. This overlap in the northward and southward directions was determined by the structural movements as well as by the denudation of the older rocks.

In this area, again, the so-called Aqueduct Grit, a highly felspathic grit developed near Trevor, east of Llangollen, is probably a true representative of the Millstone Grit of the Pennines, and is found nowhere else in this district.

South of the Dee Valley that part of the Limestone Series below the Sandy Limestone thins away to about 50 feet against Lower Palaeozoic rocks near Llawnt, but increases again southward to 380 feet at Porth-y-waen and Llanymynech Hill, where the lowest limestone resembles the Lower Grey Limestone, but probably represents some part of the White Limestone. Here a group of at least 60 feet of underlying shales is a purely local phase in the series.

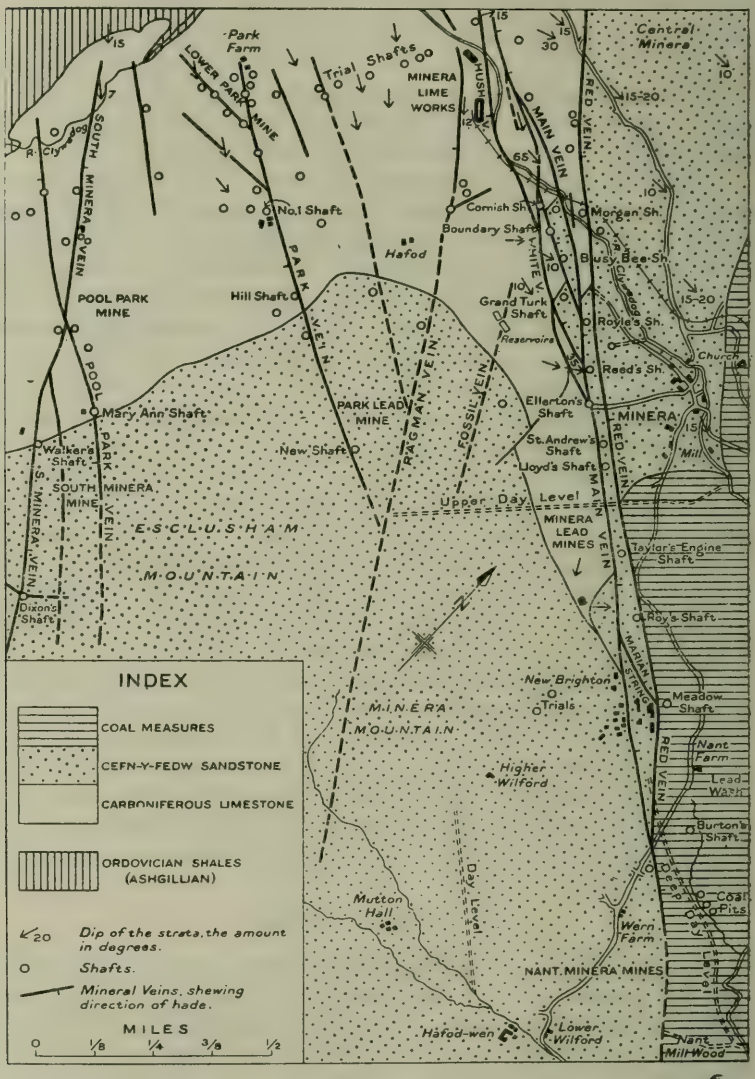
MINES AND LODES.

Minera Mines.—Lead-mines have been worked in the Minera district probably from the time of the Romans, if not earlier, down to the present day. During the last century they yielded a great quantity of ore, both galena and blende; but in 1919 only a little ore was being got at shallow depths above water-level. The largest mines are now out of work, owing to water-difficulties. It is possible, however, that in the future they may be resuscitated, for they still contain considerable reserves of ore.

On the south side of the Bala Fault near Minera the Carboniferous Limestone dips generally to the south-eastward, and on

Minera Mountain is succeeded normally by the Cefn-y-fedw Sandstone. Near Bwlch-gwyn and Minera the two formations are thrown down by a complex belt of faults with a general north-west and south-east trend, the shift in the outcrops on the

FIG. 14.—*Map of the Minera Mining District.*



two sides of the belt being a little over a mile, measured horizontally. Thus, near Tan-y-bwlch, we find the highest limestones faulted against lower limestones, followed, farther south-east, near Minera, by Cefn-y-fedw Sandstone against limestone, and again followed south and south-east of Minera by Coal Measures against Cefn-y-fedw Sandstone.

It will be convenient to describe the veins in this shattered belt in sequence, and in relation to each other where necessary, although the mines from which they were worked were opened out in different areas at various dates, the large Minera Mines being the most recent and best known (Fig. 14, p. 104).

The easternmost fault of the series, which forms a nearly clean-cut boundary, separating the faulted-down normal sequence near Minera from that of Minera Mountain, is the Red Vein—a downthrow north-east—which is practically continuous in a nearly straight line from the Bala Fault to the Wern (south-east of Minera), where it has a throw of 120 to 150 yards. Beyond this point it is not so well known as an ore-bearing fault, but it joins the Main or Old Vein, and continuing in the same direction for two miles and passing into Coal Measures, swings southward to the east of Talwrn (east of Rhôsllanerchrugog). Ore was got from it at the old Nant-Minera Mines, situated north of Nant Mill Wood, which were drained by a day-level (with two adit-shafts) opening on the Clywedog at the new Nant Mills.

North of the Wern and south-west of Minera it is closely accompanied on the west by another great fault forming the Main Vein, also a downthrow north-east, but west of Minera this vein swings away north-westward from the Red Vein.

The relations of the Red and Main Veins to each other, and the anastomosing strings and fliers off them, in the south-eastern part of the belt, are shown by the plan (Fig. 14, p. 104), and by the serial sections (Fig. 15, p. 106), arranged from south-east to north-west. In this area a strip of Cefn-y-fedw Sandstone occurs at the surface between the two veins.

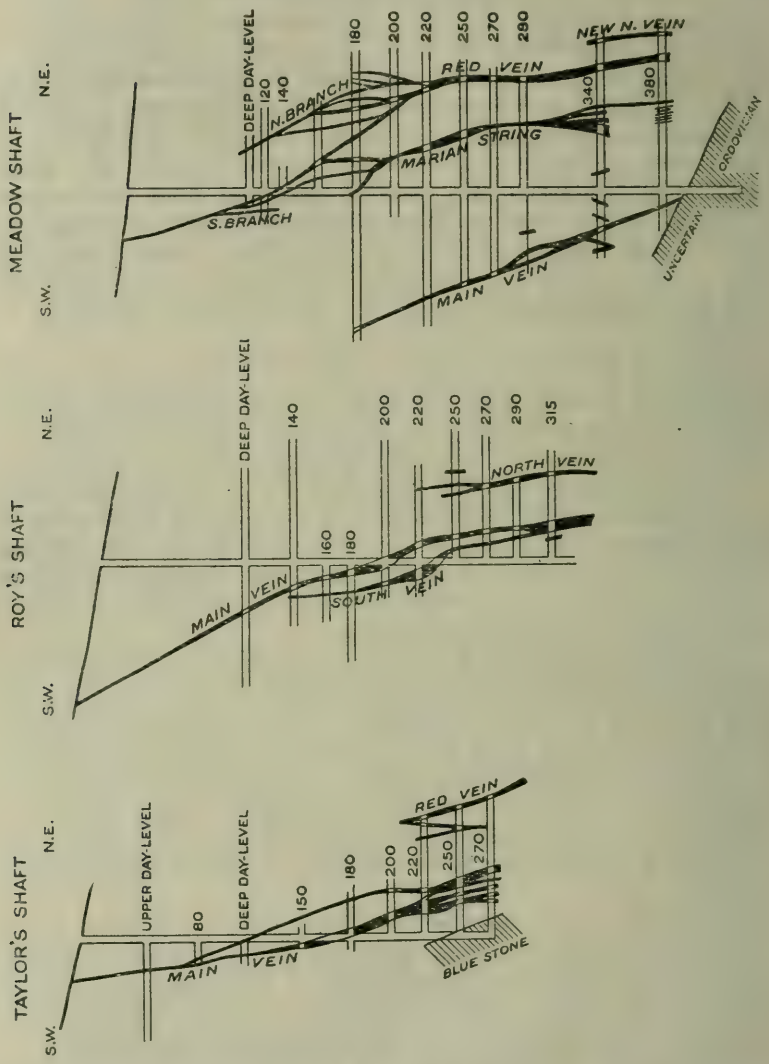
Burton's Shaft (Fig. 14, p. 104), sunk on the north-east side, traversed Coal Measures to a depth of 964 feet, the lower part being probably in Holywell Shales. Cross-cuts were made from the shaft to the Red Vein at 275 and 315 yards depth, hitting the middle of the limestone beds. The deepest level on the Red Vein was the 335-yard, the ore being stoped up to the 235-yard level to the north of the shaft and the cross-cuts. The North Lode was also worked between the 275- and 295-yard levels.

Important shafts on these veins in north-westward order from Burton's Shaft are: the Meadow, Roy's, Taylor's, Lloyd's, St. Andrew's, Ellerton's, Reed's, Reid's, Royle's, Grand Turk, Busy Bee, Boundary, Cornish, Morgan's, and the Maes-y-ffynnon Shafts, the latter being close to the old Minera Union Mine.

Between the Meadow and Roy's shafts the two veins are connected by an important cross-vein, also down east, known as the Marian String. The Meadow Shaft, after passing through limestone, entered what are probably the Lower Palaeozoic rocks below the 400-yard level. The same rocks were penetrated at Taylor's Shaft also, at about 250 yards depth; but Roy's, between the two, does not appear to have touched them even

at 315 yards. The Boundary Shaft touched them at 60 yards. The Cefn-y-fedw Sandstone occupies the surface on both sides of the Main Vein as far north-west as Taylor's Shaft, beyond

FIG. 15.—*Sections of Taylor's, Roy's and the Meadow Shafts, Minera Mines.*



which the vein separates Limestone and Cefn-y-fedw Sandstone nearly as far north as Reid's Shaft, where some lenticles of the sandstone occur west of the Main Vein in the faulted ground near the Busy Bee and Grand Turk Shafts.

At the Meadow, Roy's, Taylor's, St. Andrew's and Ellerton's shafts the Red Vein has not been worked to the surface, possibly

because it was most prolific in the Limestone that underlies the Sandstone on the west side. At Reid's, however, it becomes prolific at higher levels, where the Limestone is nearer the surface in the strip between the two veins. An upper day-level, at about 45 feet depth, issues on the River Clywedog about 120 yards north-north-east of the shaft.

Farther north it was worked up to the surface from the Maes-y-ffynnon Shaft. In this area the Main Vein is accompanied by important north-and-south branches.

Near Plâs-yn-coed, about 170 yards north-west of Ellerton's Shaft, the Main Vein throws off the White Vein, with the same hade, on its south side. This vein passes near the Cornish Shaft and joins the Main Vein near the lime-works.

The Busy Bee Shaft is sunk nearly on the outcrop of a flier connecting the south-west side of the Main Vein near Royle's Shaft with the White Vein near the Cornish Shaft. This flier hades north-eastward and is called the Busy Bee or South Vein (Fig. 14, p. 104); with the White Vein it encloses a strip of limestone and Cefn-y-fedw Sandstone. The Cornish Shaft cut the Lower Palaeozoic rocks at 90 yards depth.

North of this locality the Red Vein carries on in a nearly straight line to the Bala Fault near Peniel Chapel at Four Crosses; it appears to have been accompanied on its north side by a joint along which several shallow trial-pits were sunk, but this joint does not appear to have displaced the outcrop.

The Main Vein is joined by the White Vein about 420 yards north-west of the Cornish Shaft, on the north side of the lime-quarries, through which it runs for a distance. Joint-faces can be seen here, covered with good crystals of calcite and galena. The Main Vein then leaves the quarries and crosses Eisteddfod (Ragman sett) to the Bala Fault near Cefn-y-maes (Maes-Maelor sett), its course being marked by a line of old shafts.

On the south-west side of the Main Vein a well-marked vein —the Hush Vein—leaves the White Vein near the Boundary Shaft, and appearing to run through the lime-works and Ragman Mine, crosses Eisteddfod (in the West Minera sett) and curves westward to the Bala Fault near Top-Eisteddfod (in the Maes-Maelor sett). This vein, which underlies south, is marked by a line of open-casts and shafts.

In the mineral setts known as the Twelve Apostles, Cae-pant and Minera Union, between the Main Vein and the Red Vein, and north of the map forming Fig. 14, there are numerous old pits and shallow trenches, marking the sites of old workings on several veins. It was not possible to trace all these by surface-mapping, but they are inserted on an old map by Brenton Symons, Mining Engineer, published in 1865, from which we have derived particulars of many of the older mines in this district. Taken in order from south-west to north-east these veins are: (1), a vein supposed to be a continuation of the Ragman; (2), the Llewellyn; (3), the Sand Vein; (4), the

Crych Vein; (5), the Union Vein. They all underlie north-east and may all be fliers off the Main Vein.

To the south of the Hush Vein (outside the Map, Fig. 14) an important fault—the Rock Vein—a downthrow north, shifts the outcrop of the Limestone several hundred yards eastward on the south side. Towards the east (in the Rock and Minera Western Boundary sett) this fault forks. The northern branch is marked by a line of old workings and shafts, trending into the limestone-quarries at Ragman Mine, where it may join the Hush Vein. The southern branch crosses the quarries south-eastward as the Craig-boeth Vein. It underlies north-eastward and two joints spring off from it southward. Between the two branches is the Culvert Joint, nearly parallel to the northern branch. To the south of the large kiln of the Minera Limeworks a well-marked fault, dipping south-west at 60 degrees, trends south-eastward; this is apparently the Ragman Vein of Symons's Map and may be continuous with the Culvert Joint. Between the Ragman and the Main Vein is the Fossil Vein. Farther south a day-level has been driven north-westward from near Hafod-wen in the same direction. None of the plans of these old mines is deposited in the Home Office, and details are therefore wanting.

Practically all the above-mentioned faults and joints have proved to be ore-bearing, and the earliest mines were apparently established on the high ground on the north side of the valley of the little River Clywedog, from which day-levels and adits would have been driven in early days. The rock is full of subterranean caverns[1] and swallow-holes, and the extent of the workings is remarkable, though little now seems to be known about the veins themselves. Practically lead-ores alone were raised from these mines, though a little calamine and blende were occasionally found. At Minera Boundary Shaft, four men were working in 1919 in the higher levels above the day-level.

Before 1849 this north-western group of mines was unconnected with the great Minera Mines farther south-eastward, although water leaked from the one to the other. They were then connected by driving the day-level through from Minera Mines, a result nearly fraught with disaster to the workmen.

In the Minera Mines, blende as well as galena occurred commonly in the area south of Reid's Shaft. The average thickness of the veins was 6 feet, but they varied from *nil* to 30 feet.[2] The minerals were sometimes arranged parallel to the walls, and were often slickensided, especially the blende. The

[1] We were informed that a great cavity, 428 yards long, goes northward from the Grand Turk Shaft and passes beneath the lime-works. The water that used to accumulate in it in wet seasons could not get out of the deep adit, but rose and flooded the Grand Turk level.

[2] *See also* description of these veins in 'A Treatise on Ore Deposits,' by J. A. Phillips and H. Louis, *Lond.*, 1896, pp. 298, 299.

ores occurred in one or more strings and lenticles, the intervening spaces being filled with calcite and anastomosing strings of quartz. The galena of the Red Vein was 'steel-ore.' Shale, if present in the veinstuff, usually occurred on the hanging-walls. A greater proportion of galena than blende occurred at the shallower north-western end of the mine; it began to be noticeable at Reid's Shaft and increased south-eastward, becoming predominant in the deep levels at the south-eastern end of the mine. At Reid's Shaft the Main and North Veins carried good blende in the lower levels. The North Vein was 7 feet wide at the bottom. The Red Vein was reached by a cross-cut from the bottom of Burton's Shaft (New Minera Mine) and yielded good ore, chiefly blende, at this depth. Near this point the Main Vein contained galena, 3 feet wide; and about the year 1898, 250 tons a month were obtained from the 250-yard level. Blende obtained from the Meadow Shaft contained 61·5 per cent. of zinc.

Some extracts from old Company Reports will here be of interest, the veins referred to being the Main and Red Veins: "In the eastern direction, especially the 120-yard level (Ellerton's "Shaft) upon the north or Red Vein, has been extremely rich "during the last 12 months, for a length of 40 yards, the vein "yielded 10 tons of ore per fathom, average; and 6 men have "broken as much as 70 tons of ore in a month's driving of the "level only."[1] "The 160-yard level, driving towards it from "Roy's Shaft, is rich, yielding four tons of ore per fathom."[2] "The vein contains not only Lead Ore, but large quantities of "Blende; and this is often the best indication that we expect "rich deposits of Lead Ore below."[3]

The richest bunch of galena found at about this date (1864) was on the Red Vein between Ellerton's and Lloyd's Shafts. It was from 6 to 7 feet wide, and occurred at 220 yards depth, beneath a bed of shale. It cost the men 11*s.* a ton to work, and sold for £16 a ton, realising £500,000 in all. Silver varies between a little over 4 ounces per ton of galena at the west end of the mines and a little under 4 ounces per ton at the east end. Between Roy's and the Meadow Shaft a little chalcopyrite was found. Barytes was generally absent, and fluorspar occurred only as a curiosity.

The chief obstacle to successful mining was water. The east end (Minera) mines were unwatered partially by a day-level commenced about 1766. Before 1849 the west and east end mines were worked as separate concerns and there was no co-operation to ensure a general plan of drainage. In 1815 water from the west end found its way to the deeper parts of the east end mines through an open channel or fissure in one of

[1] Annual Reports, Minera Mines, 1862. Lent by Mr. G. F. Wynne.
[2] *Ibid.* for 1863.
[3] *Ibid.* for 1864.

the veins (? the Main Vein). From the time of this influx of water no effectual or advantageous working of the mines was possible for years. Large sums of money were expended in the installation and running of pumping-engines, and in 1817 there were seven pumping-engines at work, raising 4,000 gallons per minute. In dry seasons the bottoms of the workings were reached; but breakage after breakage of machinery occurred, and the mines were abandoned in 1823.

The Minera Mining Co., formed in 1845, continued to drive the deep day-level and eventually (*circa* 1849) connected up the east and west mines and unwatered the mines at the west end also; this drained the whole mine-field to a depth of some 75 to 80 yards lower than before. The object of the level was not only to relieve the pumping-engines, but actually to intercept the main feeder that poured into the north-western workings in time of rain or flood, an influx that no engines could control. The tapping of the water was a delicate operation, nearly fraught with disaster.

An upper day-level stands at about 46 yards from the surface at Taylor's Shaft, and issued near the old Minera Mill, south-west of the schools. Another day-level, issuing on the Clywedog near Reid's Shaft, is about 45 feet below the surface at the shaft.

At Taylor's Shaft the deep day-level is at about 108 yards depth (120 yards below datum, which is 850 feet O.D. approximately). It leaves the general course of the veins near the Wern, and issues near the New Nant Mills at about 580 feet O.D. Here a stream 3 feet wide and 1 foot deep issues in wet weather. This level carried nine tenths of the water in the mines, the remainder being pumped. In 1909, when pumping finally ceased, the following engines were raising water from a depth of 430 yards:—

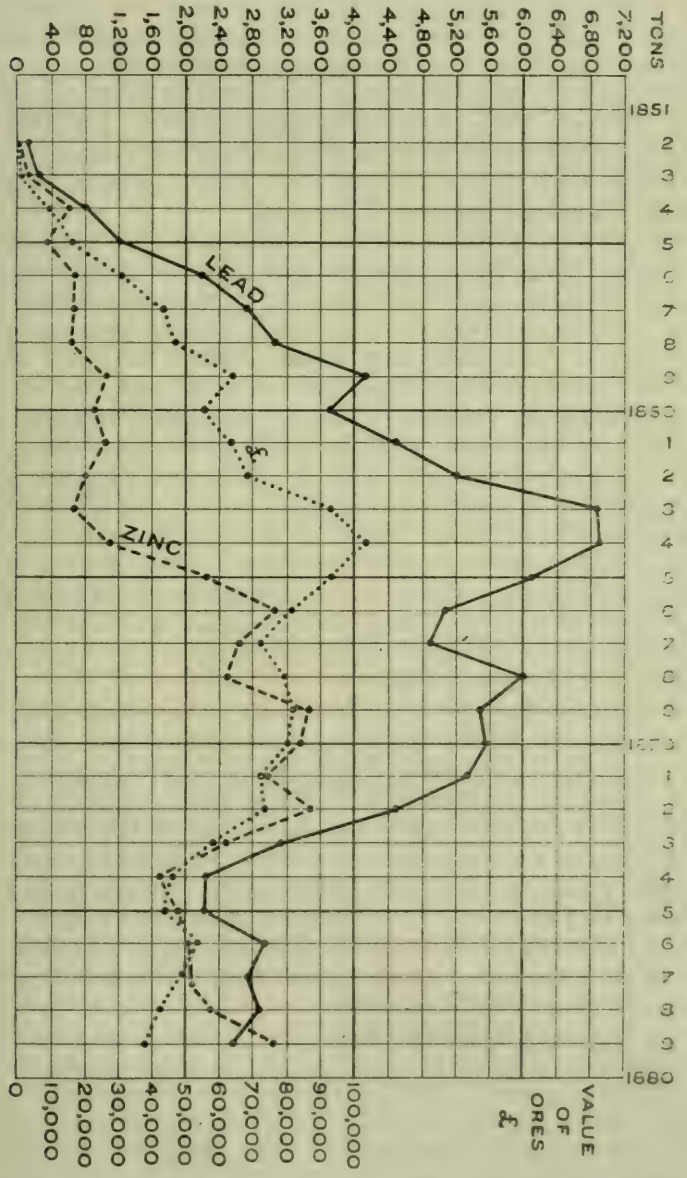
(1). At Taylor's Shaft, an 80-inch pumping-engine; lift 15 inches.
(2). At the Meadow Shaft, a 60-inch pumping-engine; lift 11 inches.
(3). At the New Minera Shaft, a 36-inch pumping-engine; lift 8 inches.

The mines are now filled up to the deep day-level. After pumping ceased in 1909—when production had fallen off and the price of ore was low—it took 18 months for the mines to fill with water. The company was wound up in 1914, the profit being made in the intervening years from ore got above water-level.

By the time that pumping was abandoned, the costs under this head were £600 a month. It is credibly stated that the Minera Mines would still be profitable but for the water, as thousands of tons of ore (chiefly blende) are left, but it is estimated by the same authority that the capital expenditure necessary to open out again would be fully £100,000. A possible method of draining by a deeper adit is discussed elsewhere (p. 29).

Between 1845 and 1909 quite £3,250,000 worth of ore was raised, the average dividend paid up to 1897 being 30 per cent. per annum. The most profitable year was 1864, when £64,000

FIG. 16.—*Graph showing Output and Value of Lead and Zinc Ores, Minera Mines.*



profit was made, the total value of the ore raised being £103,293 5*s.* 6*d.*, representing sales of 6,882 tons of galena and 1,179 tons of blende.

Tons of galena raised per month from July 1863 to June 1864.

July 1863	543	Nov. 1863	443	March 1864	650
August ,,	542	Dec. ,,	588	April ,,	666
Sept. ,,	463	Jan. 1864	653	May ,,	548
Oct. ,,	530	Feb. ,,	634	June ,,	622

The outputs and values of galena and blende from the Minera Mines from 1852–1879 are shown upon the graph (Fig. 16, p. 111). Of late years the galena assayed from 80 to 80·5 per cent. lead, and the blende from 55–59 per cent. zinc. The output of blende over galena became predominant after 1878, the year 1887, with 7,462 tons valued at £26,870, being the record year. New Minera produced 1,260 tons of galena and 4,589 tons of blende from 1892–1896 inclusive. Tailings from the mine are now sold for gravel.

Of the smaller mines in the north-western area we may note that True Blue last produced galena and blende in 1894; Minera Mountain in 1897; Minera Quarry (blende) in 1885; Union and Boundary (galena) in 1888; Twelve Apostles (galena) in 1884, and West Minera (galena) in 1882.

Other mines in the neighbourhood of Minera, but which we cannot locate, are Dean's, producing to 1907; Graig-poeth to 1887; Great Melbourne to 1883, and Llewellyn to 1887.

Lower Park and Park Mines.—These were disposed in two mine-setts lying south-west of the main group of the Minera Mines, the former to the north-west upon the outcrop of the Limestone, the latter to the south-east, partly upon the Limestone and partly upon the Cefn-y-fedw Sandstone (Fig. 14, p. 104). The chief, or Park, Vein, a downthrow south-west, trends W. 27° N. over a distance of little over one mile. No plans are preserved at the Home Office.

Numerous shafts were sunk in the Lower Park area, where two nearly parallel east-and-west veins lie on the south side of the main vein. The old No. 1 Shaft of the Park Mines (a pumping-shaft) is situated half a mile south-south-west of the large kiln at the lime-works and was sunk on the south side of the outcrop of the Park Vein. In 1865 it was 140 (? feet) deep.[1] The Hill pumping-shaft, 200 (? feet) deep, lies about 330 yards eastward on the vein. Two more old shafts occur between this and the abandoned New Shaft, situated about 600 yards away and sunk into dark compact limestone. This was a winding-shaft, and was 210 (? feet) deep.

On Symons's Map the Park Vein is shown as extending to the Ragman Vein, where it is cut off at a point near to where the upper day-level passing Taylor's Shaft (p. 110) in the Minera Mines touches the Ragman Vein. To the north of the Park Vein are two other parallel veins, the northern of which, according to Symons, meets the Ragman.

[1] These figures are from Symons's Map. Whether they are fathoms, yards, or feet, is not stated.

The Park Mine is said to have paid well at first, but did not go deep, the bottom level not being remunerative. The first body of ore found is reported to have been a flat. In one period of three months, £3,000 was paid in royalties to the Duke of Westminster, mostly from the Park Mine. In later years much money was lost in unprofitable work, though there was little trouble with water. An output of 280 tons of galena was secured between 1872 and 1880, and 335 tons of galena and 610 tons of blende between 1882–5, after which the mine was closed. Lower Park returned its last output (5 tons of galena) in 1863.

Pool Park and South Minera.—These setts (6-inch Denb. 27 S.E.) lie to the south of those of Lower Park and Park. Between the two is a small vein with a trend parallel to the Park Vein. In the Pool Park sett the Limestone is at outcrop, but towards the east the Cefn-y-fedw Sandstone overlies it, and the veins have been followed beneath it into the South Minera sett. Two well-marked veins cross one another at a small angle, namely, the Pool Park Vein, a downthrow south-west, trending about W. 35° N., and the South Minera Vein, a downthrow north-east, trending about W. 55° N. They intersect at a point, near two or three old shafts, about 400 yards north-west of the old Mary Ann Shaft, which is situated 980 yards south of No. 1 Shaft of the Park Mine. The trends of these veins are indicated by several old shafts, sunk on the outcrop or hade. Pool Park closed after 1874; it produced about 1,500 tons of galena between 1861 and 1869.

Towards the south-east the ground between the South Minera Vein and the Pool Park Vein is crossed by a flier off the former, running parallel to, and about 130 yards from, the latter. The South Minera Vein, passing out of the Pool Park sett into the South Minera sett (Denb. 27 S.E., 28 S.W.) was worked from Walker's Shaft, situated 250 yards south-south-west of the Mary Anne Shaft About 330 yards farther south-east it was worked at Dixon's Shaft, where the old head-gear is still standing This shaft passes through Cefn-y-fedw Sandstone into the Limestone, and is 420 feet deep. The tip-heap contains bastard 'Aberdo' limestone with large productids; chalybite occurs on the joints. Black shale with *Fenestella* was the last material to be raised.

The mine was partly unwatered by a day-adit, known as the Gomerian Level, driven from a point 440 yards west of Cae-llwyd (six-inch Denb. 28 S.W.) in a north-north-west direction, partly along the course of the South Minera Vein, which it follows for nearly half a mile, to Dixon's Shaft, a total distance of one mile. Dixon's Shaft stands approximately 1,440 feet above O.D., and the water-level before tapping was 300 feet from the surface; after tapping it fell to 390 feet below the surface, *i.e.*, about 1,050 feet above O.D., which is little above the height of the tunnel-mouth. An adit-shaft,

near the intersection with the Caunter Lode, almost half a mile south-south-east of Dixon's Shaft, touches the tunnel at 240 feet depth, and a second shaft, 450 yards farther in the same direction, touches it at 120 feet depth. Several other adit-shafts were sunk to this tunnel.

The above-mentioned veins are said to have been explored in the Limestone only. In the South Minera sett two other important veins, about 140 yards apart, occur west of Dixon's Shaft. They bear several degrees north of west and underlie north. The northern or Gwter-Siani Vein is indicated by several old shafts (one being a whim-shaft), the easternmost of which is Dixon's. The southern or Nant-y-cwm-mawr Vein is also indicated by several shafts near Gwter-Siani.

South of these lies the *Wynnstay* sett (Denb. 27 S.E., 28 S.W.), with the Wynnstay Vein and the Caunter Vein, the former underlying northward and trending west-north-west, the latter west-south-west. The former is marked by a line of old shafts, shallow at the west end. The Wynnstay Shaft is situated 1,100 yards west-south-west of Dixon's, whilst Youde's, which penetrates Cefn-y-fedw Sandstone to the Limestone, lies in the valley of Nant-y-cwm-mawr and about 900 yards east-south-east of the Wynnstay Shaft. The tip contains smooth dark limestone and dark shales. The Caunter Lode is supposed to meet the Gomerian Level a little south of the first of the above-mentioned adit-shafts ; it was reached by an old shaft half a mile south-east of Cefn-y-gîst. In this area the Cefn-y-fedw Sandstone occupies the surface, the lode occurring presumably in the underlying Carboniferous Limestone.

Between the westerly-diverging Wynnstay and Caunter Veins lie the old *Cefn-y-gîst Mines* (Denb. 27 S.E.), which exploited the Cefn-y-gîst and Youde's Veins. The former runs a little north of east and slightly displaces the latter, which trends a little north of west. They pass eastwards into the Cefn-y-fedw Sandstone area, beneath which they were partly worked. The Cefn-y-gîst Vein, in the western part of its course (near the West Cefn-y-gîst sett), is vertical and is marked by several old shafts. There is an old lead-wash near Cefn-y-gîst. At the eastern end of the vein a shallow shaft penetrates Cefn-y-fedw Sandstone into grey or blue compact and fossiliferous limestone. The vein last yielded galena and blende in 1883. The Youde's Vein hades northward and its course is marked by two or three old shafts.

An adit driven eastward from near the foot of the limestone escarpment, half a mile west of Cefn-y-gîst, commences in Ordovician shales and ends in dolomitic limestone.

To the south lies the old *Eglwysegle Mine*, on the World's End or Eglwysegle Vein. The fault in which this lode occurs displaces the Limestone outcrop eastward on its north side, and also displaces the Cefn-y-fedw Sandstone. It runs between Craig-y-forwyn on the north and Craig-y-cythraul on the south,

varying from a direction a little south of east to an easterly direction which, in the Cefn-y-fedw Sandstone outcrop, becomes east-south-east, nearly coinciding with a peat-filled hollow. The lode is marked by numerous old shafts and surface-diggings, stretching eastwards from Craig-y-cythraul. Three shafts about 200 yards east of the western margin of the Cefn-y-fedw Sandstone have gone down to the Limestone, but two—460 and 750 yards farther east-south-east respectively—do not appear to have penetrated the Sandstone. A branch with a south-east direction leaves the vein near Ty-uchaf and crosses Craig-yr-adar. An old adit was driven on the lode in the ravine beneath Craig-y-cythraul. The water-level here is affected by the pumping at the Talwrn Waterworks.

On Symons's Map two veins are shown to the north. The first, or Bean Vein, underlies north and runs a little south of east-north-eastward, through the north end Craig-y-forwyn, more or less parallel to the Caunter Lode. In the Cefn-y-fedw Sandstone it appears to continue beneath an old shaft sunk to the Limestone. The second vein, termed by Symons the Eglwysegle, is a downthrow south and branches off from the former, trending a little south of east. No signs of this lode appear at the surface, and it is not clear whether it was not meant by Symons to represent the Main Vein described above, although both its hade and position are different. Eglwysegle Mine and its Extension last furnished galena in 1870.

Farther south two veins, of which little is known, traverse the Limestone in an east-south-east direction, the first near Plâs-Eglwysegle, the second on Y-craig-bensyth.

Bwlch-gwyn.—On the south side of the Bala Fault, near Bwlch-gwyn, lead has been worked from five veins, shown on Brenton Symons's Map of 1865; the northern vein trended east-north-eastward and the southern east-and-west, those between having intermediate positions. The old Geological Map, 74 N.E., shows this group of veins, crossed, however, by three cross-courses, trending west of south and tending to converge in that direction. At outcrop the ore-bearing fractures are in the Cefn-y-fedw Sandstone, which dips east-south-eastward, and small veins of lead-ore are occasionally found to-day in stone-quarries in this neighbourhood. The underlying Limestone also may have yielded ore, although limestone is not noticeable in the old tip-heaps.

The southern or east-and-west vein lies just north of the cross-roads near Bwlch-gwyn Church, the old shafts being situated on the north side of the Ruthin road. Other old shafts on the other veins lie farther north, in Coed-mawr, on the southern slope of Nant-y-ffrith.

Bwlch-gwyn Mine yielded 30 tons of ore in 1850, and up to 1857, when the mine was closed, had produced 1,741 tons of galena. In 1861 about 5 tons were got, but nothing seems to have been done since that date.

A mine named 'Coed Poeth,' which last yielded ore (23 tons) in 1857, we have been unable to locate. It may well have been one of this small group operating near Bwlch-gwyn.

Llanymynech Hill.—Near Oswestry, many miles farther south, the outcrops of several veins occurring in the Carboniferous Limestone of Moelydd, about 1½ miles west-north-west of Porth-y-waen, are marked by a large number of shallow pits. These veins, which are shown on the Old Series One-inch Geological Map 74 S.E., are faults containing spar, but it is doubtful whether any lead was found here, although the symbol for lead-ore appears on the map mentioned.

On Llanymynech Hill, however, both lead and zinc ores have been mined in past years. In some cases the lead-ores occurred in association with the copper-ores that were mined by the Romans,[1] and although there is little direct evidence for concluding that the Romans worked the lead-ores, they probably did so when they found them during their search for copper. The chief copper- and lead-bearing vein (*see* Geological Map, 74 S.E.) trends north-north-east along the east centre of the south end of Llanymynech Hill, crossing the golf-course slightly west of the pavilion. It underlies east, and its course is indicated by a series of shafts on the vein, and by shallow surface-workings in which the ores were probably won in the same manner as that from the lead-flats of Flintshire. Towards the north end of the vein there is the cave-like entrance to an adit, locally known as the 'Ogof.' Gwallter Mechain writes: "The Romans followed this vein of copper from the Ogov the "whole length of the hill towards the east [? S.W.], which is "evident from innumerable cavities now in the surface and in "that direction. Both copper and lead ores are still dug up "here; but the work has been in a declining state for some "years. I have seen here nodules (called by the miners "tumblers) of pure galena, weighing above one hundred "pounds each. Besides this sulphate [*sic*] of lead, I have "found here some of its white and yellow carbonate. . . . "Here are other ores which the Romans never knew, I mean "zinc in both its unions, with the carbonic and sulphuric "acids; the former very plentifully."[2]

At a still earlier date Pennant[3] remarked that "Copper, lead "ore and calamine, have been found there of late years; and "there are undeniable proofs of its having been worked by the "Romans. In a great artificial cave (Ogof) formed into several "meanders in search of the ores, have been discovered *Roman* "coins; among them an *Antoninus* and a *Faustina*."

Farther north on Llanymynech Hill several old shafts and levels have been made, in search of copper or possibly lead.

[1] *See* forthcoming Report on Copper Ores (*Mem. Geol. Surv.*).

[2] 'Llanymynech and District. Notes from The English Works of the Rev. Walter Davies, M.A. ('Gwallter Mechain')," *Lond.*, 1868, p. 10.

[3] 'Tours in Wales,' vol. iii, 1810, p. 218.

CHAPTER V.

MINES RECENTLY SUSPENDED, AND WORKING MINES.

In the following account of the mines still working or only recently suspended, a geographical arrangement has been adopted, commencing in the north.

Waen and Merllyn Mine.

Waen Mines Ltd., Pendre, Holywell.

Shaft situated on the east side of the road about 100 yards S. of Waen, three quarters of a mile S.S.E. of Whitford.

Maps.—One-inch Old Series Geological, 79 N.E.; New Series Ordnance, 96; six-inch, Flintshire 5 N.E.

Lat. 53° 16′ 58″. Long. 3° 16′ 10″. Height above O.D. about 550 feet.

History and Geological Occurrence.

The Merllyn Lode worked here was cut in the driving of the Gorsedd day-level southward from Tre-Eden-Owen. The level, "happening at that point to traverse a bed of shale 2 feet "thick, showed the vein as well defined, but containing only a "thin leader of spar. The level was re-opened about 1878; at "300 yards from its mouth at Tre-Eden-Owen the roof had "fallen in, and a new adit was driven round the broken ground "for a distance of 60 yards. In this part the level traversed "shale with a thin seam of coal, but southwards passed directly "into Black Limestone, the Chert Beds having been cut out, as "it is supposed, by a fault. At Waen the Merllyn Lode "crossed the level in a bed of shale, as above mentioned, but "when followed down below the shale into the limestone, "developed into a good vein . . ."[1] Another east-and-west vein has been cut on the latitude of Waen Farm.

The main shaft is 90 yards deep and 9 feet wide, and intersects the Merllyn Vein at 70 yards. The section is as follows (Fig. 4, p. 56):—

	Feet.
Clay, gravel, and sand (Glacial deposits)	45
Black limestone (used for hydraulic cement) ...	57
Greyish-brown and hard grey limestone	168
	270

[1] 'The Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, pp. 167, 168.

"The vein hades to the north, and a few yards west of the "shaft is crossed by a joint bearing north-north-west, by which "it is thrown down a few feet to the west (the apparent effect "being a shift of the vein 7 yards southwards on the western "side of the joint in each level). A second joint, 25 yards "further west, shifts the vein still further, so far as could be "seen in 1879."[1] These joints and the cross-course run a few yards west of the Gorsedd Black Limestone quarry and are known as the Quarry Vein. A trial-shaft was sunk on them near the cross-roads at about 590 feet O.D.

The vein averages 2 to 3 feet in width, with clear and well-defined foot- and hanging-walls. Levels are laid out at 50, 70, and 90 yards depth the first being connected with the Gorsedd day-adit, into which the water is pumped. Prospecting was carried out and some ore raised between 1910 and 1913, and it was proved that in the levels, especially the 70- and 90-yard, there are several productive points (Fig. 4, p. 56), with galena and blende, where operations could be commenced immediately. Westward, beyond the cross-course, there appears to be a considerable area of virgin ground. The cross-course carries galena in bunches, but apparently no blende. In 1913 the output was 37 tons of lead-ore, valued at £499, and 35 tons of blende, valued at £211. Assays have given the following figures: lead up to 82 per cent. in the galena; zinc up to 52 per cent. in the blende; silver up to 12 or 13 ounces per ton of galena.

Mining.

The mine is standing until labour-troubles have settled down, but the plant is ready to start working at any date. Water could be cleared in about a month, and could then be kept down in winter-time by 8 hours of pumping per day, with a 7-inch lift. In summer-time water is pumped to the surface for use in the concentration-plant, which is ready to resume operations.

The Milwr Tunnel and the Lodes Cut.

The Holywell–Halkyn Mining and Tunnel Co., Ltd., Pendre, Holywell.

The history of the Milwr Tunnel and the objects for which it was undertaken, as well as its general course, have been described in the Introduction, pp. 26–28. The following is a more detailed account of the operations, of the old veins cut, and the new ones that were discovered.

Geology and Mining.

The tunnel mouth is situated at Dee Bank, Bagillt (Fig. 2, p. 24), between Bettisfield Colliery and a lead-smelting works,

[1] *Op. cit.*, p. 168.

at about 9 feet below mean high-tide level. The driving takes a straight course south-westward, with a rise of 1 in 1,000, to the Herward Shaft (p. 120), 2,990 yards away. An Intermediate Shaft, sunk 390 feet deep for the purpose of tunnelling, but now disused, is situated 1,360 yards from the Herward Shaft.

The ground traversed by this first section of the tunnel consisted of the following rocks ;[1] the figures give the number of feet excavated in each formation :—

	Feet.
1. Alluvial deposit	240
2. Boulder-clay and sand and gravel	279
3. Coal-measures, including freestone	1,839
4. Lower Coal Measures or Holywell Shales ...	5,691
5. Chert (the lead-bearing formation)	921
	8,970

The Lower Coal Measures were found to contain bands of cement-stone from 6 inches to 6 feet thick, and seams of grit from 3 inches to 4 feet thick, with frequent beds of argillaceous limestone.

The first 108 feet of the Intermediate Shaft were sunk in boulder-clay, sand, and gravel ; but from that depth to the level of the tunnel the ground consisted of strong black shale.

The boundary-fault between the productive Coal Measures and the Holywell Shales was found within a few yards of the estimated position shown on the Geological Map. It was 4 yards wide, well-defined, oblique to the driving, and gave considerable trouble owing to its being full of sandy warrant, and of gas that drove the warrant into the tunnel.

The boundary between the Holywell Shales and the underlying Cherts was passed 307 yards north-east of the Herward Shaft. From this point the ' north cross,' designed to cut the Beili-gwyn Vein of the Milwr Mine at the 200-yard level, and also the Old Milwr Vein, was driven along the boundary. These operations are described under Milwr Mine (pp. 125, 126).

Previously the Herward Shaft, the upper 210 feet of which are in Holywell Shales (Fig. 17, p. 120), had been flooded to a depth of 70 yards, its bottom being 20 yards below tunnel-level. The tunnel was driven through very broken ground to the shaft (600 feet deep) which it struck centrally, and the water was safely drained away.

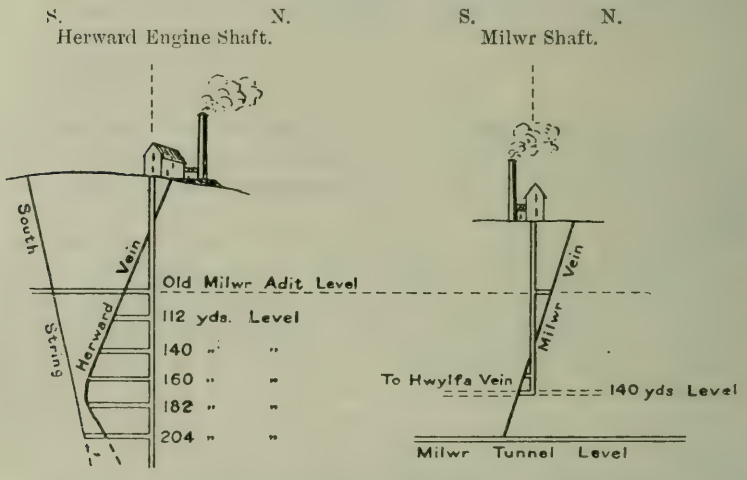
Turning south-south-westward towards the North Henblâs Shaft (670 feet deep), the Old Hwylfa Vein was passed without being recognised, but was found at a higher level in a cross-cut from the Milwr Mine (p. 125). At North Henblâs the Pen-yr-hwylfa Lode was found at tunnel-depth a little south-east of the

[1] J. P. Jones, ' Holywell–Halkyn Tunnel and Mines, Holywell, North Wales,' *Trans. Manch. Geol. Soc.*, vol. xxxi, 1908–1910, pp. 16–21. *See* p. 19 and Pls. IV and V.

shaft and driven upon for 48 yards westward. Galena was got and stoped upwards into old workings from the shaft-bottom, some 50 yards above. The lode was struck close to the boundary of the Limestone and the Chert, and patches of galena and blende were found here. It has not been worked upon into the Cherts to the east. The North Henblâs Shaft was about 535 feet deep,[1] and the trend[2] of the lode was here W. 28° S.

The tunnel next turns south-eastward with the strike of the Limestone, the next lode struck being the Dolphin at a point

Fig. 17.—*Sections of Herward and Milwr Shafts.*



about 210 yards from North Henblâs Shaft (or 410 yards north of Coronation Lode). At tunnel-depth this lode hades southward and trends N. 73° W. The lode was driven upon for 10 yards eastward, when the base of the Chert was reached. Years ago a shaft was sunk on the Dolphin Lode and a quantity of ore got, but trouble with water ended the venture. The shaft was about 288 feet deep.

The Drill Lode was cut 340 yards south-east of North Henblâs Shaft (or 280 yards north of Coronation Lode). It was nearly vertical and trended magnetic east-and-west (*i.e.*, W. 18° S.). A driving, which did not reach the Chert, was made for about 7 yards eastward in a joint with 3 inches of clean solid galena. The Old Drill Engine Shaft was about 256 feet deep.

The Coronation Lode is a new lode cut beneath Pentre-Halkyn Farm, about 280 yards north of the Caeau Shaft. The lode was hardly perceptible where cut and very little water was tapped, but the ground changed abruptly from limestone to

[1] Jones, *op. cit.*, Pl. V.
[2] Taking the magnetic declination as 18 degrees.

chert and bastard limestone. A driving was put on it westward for two yards, when it opened out into a strong joint and a bunch of about 70 tons of galena was found in a veinstuff of chert and bastard limestone, between walls of chert and limestone. The lode opened into a large joint and then split into two open joints, each 12 inches wide, which continued south-westward and would eventually intersect the Caeau Lode. The trend of the lode is W. 46° S., and the hade is south-eastward, but the joints at 40 yards from the tunnel are nearly vertical.

The Caeau or Pant-y-pydew Lode (*see* New Caeau Mine, p. 126), where intersected by the tunnel at a depth of 227 yards, proved to be dry. South of the shaft, which is a few yards west of the tunnel, the ground is chiefly chert and black sandy shales ('blackstone') and bastard limestone, and these continue for 260 yards, when the Limestone is entered again. Dips taken by Capt. J. Francis on the last day of operations (25 Aug. 1919) show that these beds form a synclinal trough pitching eastward. Near the foot of the shaft the dip is S.E. at 15 degrees, but 40 yards farther south it swings round to N.E. at 5 degrees, and thereafter increases to N.E. and N.N.E. at 20 degrees and finally to 36 degrees. The Grey Limestone then comes in beneath it, dipping N.N.E. at 44 degrees.

At the point of intersection the lode consisted of 3 feet of white calc-spar (at this depth it is usually stained), with no ore. A driving was made eastward for 20 yards, when a cross-course throwing the lode 4 yards southward was intersected. The driving was continued 50 yards farther in a joint yielding 4 to 6 inches of blende, but no galena. Limestone came in at the end of this joint and the vein pinched out. At 30 yards farther back, a cross-cut southward picked up the lode within 15 yards. It was 3 feet in width, the matrix, which yielded water, being loose broken chert, 'blackstone,' and spar. Much water came down the cross-course from above. Where the shaft intersected the lode near the tunnel there were 9 inches of blende, but no galena.

The Caeau Mine (p. 126) was unwatered by putting up an inclined rise from a point on the lode 4 yards west of the tunnel, but still east of the shaft. The rise went up 18 yards in dry fairly solid ground, when an enormous body of mine-water was tapped. Spar occurred in the rise on the lode, which was well-defined up to a point 15 yards below the 154-yard level (p. 127), when broken ground was entered like that in the sumps.

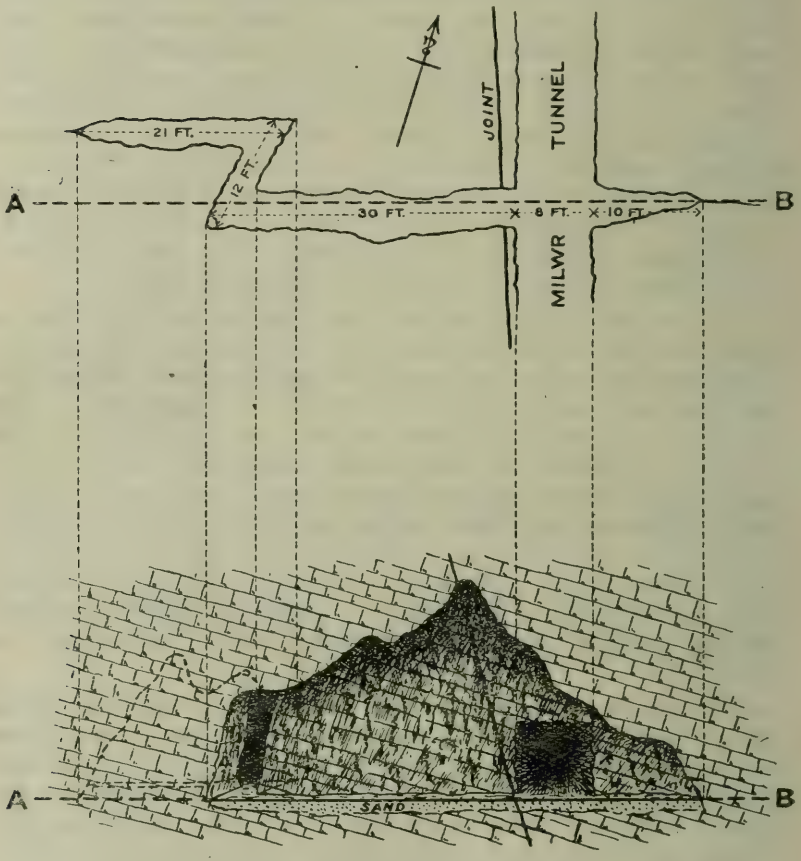
Water was struck at the junction between the grey limestone and the bastard beds, 260 yards south of the Caeau Lode, and from this point the tunnel is driven in limestone right up to the boundary of the Holywell–Halkyn drainage-area at the Windmill, a distance of 1,420 yards. About 1,200 to 1,500 gallons per minute of water were tapped at the Erw Vein, 290 yards south

of the junction. Of the Erw Vein, which is almost on the line of Parry's Vein (p. 64), little or nothing is known.

Between this vein and the Pant Lode, 350 yards farther south, numerous thin stringers of blende and a little galena were found. One or more of these doubtless represented Grainger's Vein (p. 64).

At the Pant Lode, cut on 5th January 1917, at 6 a.m., a large burst of water occurred after firing, the heading of the tunnel having broken into a large cavern or vugh (Fig. 18)

FIG 18.—*Loch or Vugh on the Pant Lode, intersected by the Milwr Tunnel.*



Upper figure in plan, lower in section.

filled with sand and water. The flood swept loaded tubs a long way down the tunnel until they jammed, and the tunnel was partly choked by the sand, which accumulated to a depth of 2 feet at the mouth. As a further result, St. Winifred's Well, Holywell, decreased its flow and dried up by 5 p.m. that day (pp. 27, 28). The temperature of the water entering from

the west was 48°–49° F.; that from the east was 56° F. Gaugings taken on 17th January showed a flow of 6,000 gallons per minute, which fell off to 4,155 gallons per minute by 16th February. The sand appears to be largely composed of quartz-crystals and chert-grains. It consists of pale-buff moderately fine-grained but unevenly graded material with a few pebbles, mainly of limestone and chert, up to the size of a pea. When separated by heavy solution it was found to contain a fair proportion of iron-ore grains and the usual small zircons. The light residue that constitutes the bulk of the sand consists almost entirely of small brilliant doubly-terminated quartz-crystals, with a subordinate amount of pale-coloured to white chert occurring more especially as grains of larger dimensions. The chert consists of an aggregate of minute quartz-particles set in a silicious matrix. The quartz-crystals are remarkable, on the whole, for their slender form, their length being in general at least five times their breadth.

This sand has evidently been derived from the disintegration not only of the silicious veinstuff, but also of the walls of the veins, which, in the case of the limestone, have had their calcite subjected to metasomatic replacement by quartz (p. 13).

Other vughs also were found to be choked with sand and gravel, which had to be raised from the shaft to avoid choking of the tunnel. The Pant Lode, which hades southward, has not been followed up at tunnel-level.

About 150 yards farther south a cross-course, cutting the tunnel obliquely from north to south, was followed for several yards. At two points 1,000 gallons of water per minute were tapped. This water may have been that entering the Pant Lode from the east, and the cross-course may be the continuation of the Pant-y-ffrith cross-course (p. 68), a downthrow west.

A small lode, with a downthrow north, was cut at 510 yards south of the Pant Lode and 260 yards north of the boundary. It is nearly on the line of the old Chwarel-lâs Vein (p. 66).

Beneath the Windmill, at the extreme end of the tunnel, a winding loch or vugh, with a peculiar course seemingly independent of structural planes and crossing the tunnel more than once, was broken into. Water amounting to 300 gallons per minute was tapped here, at the present extremity of the tunnel, which must be very close to the position of the Union Vein (p. 66).

In driving the tunnel southward most of the western feeders north of the Pant Lode dried up successively, but strong feeds still enter the tunnel from the east.

The total flow of water from the tunnel mouth in winter is estimated at 12,000 gallons per minute. The mouth is protected by two self-acting doors, and provision is made for keeping back the sea-water when the tide rises.

From the northern part the tunnel, which is circular in section and 8 feet in diameter, the material was removed from the tunnel-mouth and the Intermediate Shaft (p. 119), and at one period three headings were being driven simultaneously. In the southern part of the tunnel, which is square in section, the material removed was raised at Caeau Shaft and dumped at the shaft-head. The cost of driving from the mouth to Herward Mine was £4 a foot. The greatest speed of driving was attained in the Holywell Shales, and was 54 feet a week. South of the Herward Shaft the cost fell to £2 6*s.* 8*d.* a foot, before the outbreak of war. Since that time the working-costs have of course risen.

From a point 70 yards south of the Caeau Shaft the driving was continued southward to the Windmill boundary by the Holywell–Halkyn Mining and Tunnel Co. on behalf of the Halkyn District Mines Drainage Co.

Milwr Mine.

(*Standing.*)

Holywell–Halkyn Mining and Tunnel Co., Ltd., Pendre, Holywell.

Situated at the hamlet of Milwr, about a mile S.E. of Holywell.

Maps.—One-inch Old Series Geological, 79 S.E.; New Series Ordnance, 108; six-inch, Flintshire 6 S.W.

Milwr Shaft: Lat. 53° 15′ 40″. Long. 3° 12′ 33″.

History.

This mine was opened before 1754 (p. 57), at which date it is recorded that a day-level was commenced to drain the Milwr and Herward Veins. Milwr Mine was worked from 1888 to 1895, the deepest level on the Beili-gwyn Lode being 138 yards (Fig. 19, p. 125). Old Milwr was worked from 1898 to 1901, whilst the Beili-gwyn was worked by the present company from 1904 to 1912, the lode having been located in a cross-cut off the Milwr Tunnel (p. 119).

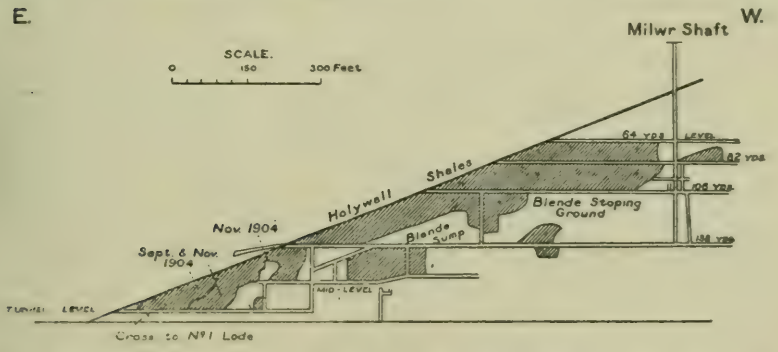
Geology.

In this mine the Holywell Shales dip about east-north-eastward at 22 degrees, off the Cherts, which crop out to the west. The chief veins from north to south (p. 57) are the Milwr and the Beili-gwyn, the former being a downthrow south, the latter a downthrow north. Between these is the Ellis or Woodlands Joint or Vein, which, unlike the others, does not displace the outcrops of the rocks. Farther south are the Cornel-pylle and the Old Hwylfa Veins.

During the driving of the Milwr Tunnel from Bagillt to the Herward Mine (p. 119) a cross-cut was driven, from a point 310 yards north-east of the Herward Shaft, in a general north-westward direction along the boundary between the Holywell Shales and the Cherts, in order to cut the Beili-gwyn and Old Milwr Veins. This cross-cut at tunnel depth is the 200-yard level in the mine. The Beili-gwyn lode was successfully found at a distance of 130 yards from the tunnel; but the driving, on being advanced 217 yards farther, failed to pick up the Old Milwr Vein, although a belt of disturbed ground, in which trials were run, was encountered near the end. Four headings were driven westward off this north cross-cut, the second being on the Beili-gwyn.

A further attempt was made to cut the Milwr Vein from the 138-yard level in the Beili-gwyn Lode. The cross-cut, commencing about 90 yards east-south-east of the shaft, was driven

FIG. 19.—*Section of Beili-gwyn or No. 2 Lode, Milwr Mine.*



for 193 yards north-eastward. It also reached disturbed ground. A turning northward was made here and a little galena and blende found, but not followed up.

The Beili-gwyn Lode was worked between tunnel-level and the 138-yard level (the lowest workings in the old mine), and also above that level (Fig. 19).

In the Cherts the vein is badly defined, consisting of many little flats and vertical strings in a broad belt of ground (*cf.* East Pant-y-gôf Lode, p. 130). Farther west, in the Limestone, it is better defined.

From a point 240 yards east of the shaft, and not far from the point where the Holywell Shales come in, an 81-yard cross-cut was driven west-south-westward, at the 138-yard level, to the Old Hwylfa Lode, which was found at the calculated position. Ventilation, however, was poor, and the trial was abandoned. The lode was of a fair size, with an 8-inch seam of blende yielding about 3 tons to the fathom, but the walls were not well in view. This lode was not recognised in the Milwr Tunnel (p. 119).

From 1888 to 1895 the Milwr Mine yielded 625 tons of lead-ore and 3,112 of zinc-ore. Between 1898 and 1901 Old Milwr yielded 623 tons of lead-ore and 512·5 of zinc-ore. From 1904 to 1912 about 1,024 tons of galena (averaging 82·5 per cent. of lead) and 2,644 of blende (averaging 52·7 per cent. zinc) were got from the Beili-gwyn Lode.

Mining.

The Milwr Shaft is 138 yards deep and enters the Cherts at about 90 yards. The Hwylfa Shaft is 135 yards deep.

Difficulties with water were trivial, since all the above-described operations took place at or above tunnel-level. The chief obstacle to working was coal-gas, which gave trouble at the end of the 'north cross.' An explosion occurred in a rise above the Blende Sump (Fig. 19, p. 125).

The ores were carried in tubs drawn by ponies to the dressing-floors erected at the tunnel mouth. Owing to the low gradient of 1 in 1,000 each pony could haul out 25 tons of ore per diem.

New Caeau Mine.

The Holywell–Halkyn Mining and Tunnel Co., Ltd., Pendre, Holywell.

Situated 300 yards S. of Pentre-Halkyn Farm and 230 yards E. of Caeau Farm, 1½ miles N.W. of St. Mary's Church, Halkyn.

Maps.—One-inch Old Series Geological, 79 S.E.; New Series Ordnance, 108; six-inch, Flintshire 9 N.W.

Lat. 53° 14′ 51″. Long. 3° 12′ 12″.

History.

The Caeau or Pant-y-pydew Lode was worked from the Old Caeau, Rhydfudr and Llongle mines from about 1834 to 1848 and thousands of tons of ore were obtained. These mines were abandoned owing to heavy water and poor ventilation. Between 1910 and 1912 a little ore was got by the Holywell–Halkyn Mining and Tunnel Co. from beneath the old workings of the Caeau, Rhydfudr and Llongle shafts, but above the new tunnel-level.

Geology.

The Caeau Engine Shaft was deepened from a depth of about 124 yards to 141 yards in the Cherts, which, at the shaft-bottom, dip westwards, the upper 80 yards or thereabouts being in the Holywell Shales. Levels were run out at 134, 141 and 154 yards depth, the first being driven eastward on the vein for 300 yards, and passing beneath the old workings of the Caeau, Rhydfudr and Llongle shafts. The lode having

failed on the 154-yard level at a point 372 yards east of the Caeau shaft, a cross-cut was made to the north for 80 feet and the lode again picked up and followed eastward for a further 160 yards to the boundary of the Holywell Shales, which overlie the Cherts and dip eastward at 23 degrees. Thus the lode appears to be shifted northward by a cross-course.

The Chert-beds are shattered, especially in the sumps put down from the 154-yard level where the ore failed; but towards the eastern end of this level the ground was more solid and the lode better defined.

The lode hades south-south-westward and strikes E. 17° S. It was fairly well defined, varying from 6 inches to 3 feet in width. The galena occurred as 'flitches,' from 1 inch to 9 inches in width and from a few feet to a few yards in length, of clinker-like ore full of irregular cavities. It was flanked by red oxidised sandy (cherty) material, which came between it and the hanging wall, and occasionally between it and the foot-wall, but more usually it rested directly on the foot-wall. There was no blende and no calc-spar. The absence of the latter is unusual, and possibly may have some connexion with the peculiar type of ore found here. The ore had the appearance of steel-ore and was so named by the miners, but the smelters stated that it was softer and more friable. It carried 6 to 7 ounces of silver per ton.

Mining.

From the 134-yard level rises were put up to the 124-yard level to keep in touch with the old workings (carried up to the 86-yard level), which were explored thoroughly, but no ore was found. From the 154-yard level sumps were put down. Much timbering was required in the shattered ground.

All the ore was raised at the deepened shaft. By the old people the ore was brought to the 124-yard level and raised by a whimsey at a separate drawing-shaft. The main shaft has now been deepened to tunnel-level and the water drained off (p. 121), the lode being intersected below the 154-yard level. In Dec. 1909, the water level stood just above the 141-yard level. Operations at tunnel-level are described under Milwr Tunnel (p. 121).

Plâs-Winter Mine.

Bryngwiog Mines Ltd., Halkyn, Holywell.

Situated 250 yards S.E. of Plâs-Winter, 1⅓ miles S.S.W. of St. Mary's Church, Halkyn.

Maps.—One-inch Old Series Geological, 79 S.E.; New Series Ordnance, 108; six-inch, Flintshire 9 S.W.

Shaft: Lat. 53° 12′ 48″. Long. 3° 11′ 55″.

History.

The mine owes its existence to an attempt, made some time before 1890, to find the Bryn-gwiog Lode on the eastern side of the Nant-figillt Fault (p. 73). The shaft, 80 yards deep in the Limestone, was deepened to 175 yards about the year 1890, and a cross-cut driven northward to find the Great Halkyn Lode. The present company took over the mine before 1914.

Geology and Mining.

The cross-cut at the 128-yard level, driven N. 5° W., proved several lodes or joints, of which that cut 180 yards from the shaft was considered most promising, and was worked down to 171½ yards from the surface. From £2,000 to £3,000 worth of ore, mostly galena, was got from this lode; there was very little blende. The lode was followed down a sump for 44 yards, and then driven upon eastward and westward for a total distance of about 40 yards. The ore was found in lumps up to 1 cwt. in size, and was similar to that in the Great Halkyn Lode. It was hand-dressed.

At a later date a cut was driven eastward in the direction of the Cornel-y-cae cross-course (p. 132). This Cornel-y-cae driving begins 88 yards north of the shaft at the 128-yard level. At 187 yards from the north cross a level (South Level) was set off south-eastward for 55 yards on the Wern cross-course (p. 68), but this driving is 40 yards higher than the Wern driving and ends 44 yards short of its extremity. The Cornel-y-cae driving continues eastward for another 77 yards, when it swings north-eastward for about 60 yards to a point where an incline and rise were put up through country-rock. Lump-ore was found in clay. The driving was 16½ chains in length over all.

An output of 219 tons of galena was obtained between 1908 and 1913 before the present company took over.

The total output (1914 to 1918) was about 39 tons, the percentage of lead being about 78, and the silver content about 8 ounces per ton.

In 1919 two men were working in the higher parts of the mine above water-level, and getting a few tons of ore.

The Halkyn Mines.

The Halkyn Mining Co. Ltd., Halkyn, Holywell.

Lewis Shaft, situated two-thirds of a mile S. of St. Mary's Church, Halkyn.

Maps.—One-inch Old Series Geological, 79 S.E.; New Series Ordnance, 108; six-inch, Flintshire 9 S.W. and S.E.

Lewis Shaft ...	Lat. 53° 13′ 18″.	Long. 3° 11′ 7″.
New Pant-y-gôf Shaft	Lat. 53° 13′ 17″.	Long. 3° 10′ 58″.
Ladder Shaft, Great Halkyn Lode ...	Lat. 53° 12′ 52″.	Long. 3° 10′ 58″.

The New Pant-y-gôf Shaft is 200 yards S.E. of Lewis Shaft; the Ladder Shaft is 820 yards S. of the New Pant-y-gôf Shaft.

Some account of the history of the older mines worked by this company is given on pp. 68–72. The present mines owe their origin to the southward extension of the Halkyn Deep Level Tunnel (p. 23).

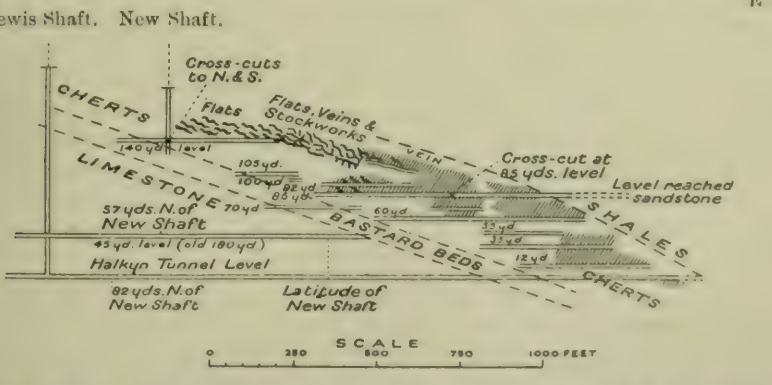
Geology.

The New (East) Pant-y-gôf Lode.—The Old Pant-y-gôf Vein is shifted 5 yards northwards on the eastern side of the Deep Level Lode. Along the Old Pant-y-gôf Vein a level from the tunnel was driven eastward in the Limestone, and another level was driven 45 yards above the tunnel, but little ore was found. Ore was discovered, however, in the Cherts overlying bastard beds above the Limestone. The Cefn-y-fedw Sandstone here consists of cherts below and true sandstone above, the two divisions being separated by a thick belt of shale, mapped at outcrop (Fig. 6, p. 71).

The new vein apparently lies to the south of the old lode in the Limestone, as proved by a cross-cut northward of 60 yards from the bottom of the new Pant-y-gôf Shaft. At the end of this cut the writer examined the Carboniferous Limestone faulted[1] against the base of the Cherts, the throw being southward at this point. Thus the hade and throw of the lode or fault representing the Old Pant-y-gôf Vein east of the Deep Level Lode appear to change from one down north to one down south. This change is probably counteracted by the new Pant-y-gôf Vein in the Cherts, which is down north.

Towards the eastern end of the mine (Fig. 20, below), a cross-cut northward, commencing in the Cherts at the 85-yard

FIG. 20.—*Section of New Pant-y-gôf Lode, Halkyn Mines.*



level above the tunnel, followed for about 40 yards a cross-course running N. 20° E., but then lost it, and was continued in the Cherts a little below the overlying shale. East of this

[1] At one point a viscid oil exuded at the junction.

cross-course the hade of the New Pant-y-gôf Vein approaches the vertical. A cross-cut driven S. 20° W. from the 85-yard level, following the above-mentioned cross-course, came into shale, about 150 yards away, dipping south-east or south-south-east. This may be a local bed, and not the shale overlying the Cherts.

The eastward dip of the beds is about 20 degrees, but steepens in that direction at the eastern end of the mine, where the shales above the Cherts come down to tunnel-level. The ore-body shoots eastward with the dip of the beds. The following is a section of the new shaft :—

New Pant-y-gôf Shaft.

	Thickness.		Depth.	
	Feet.	Inches.	Feet.	Inches.
Top of shaft to gravel ...	18	10	18	10
Gravel	12	0	30	10
Sand	21	0	51	10
Blackstone	33	6	85	4
Cherts	6	0	91	4
White stone	7	0	98	4
Shales	7	6	105	10
Cherts	27	0	132	10
Gritstone	15	0	147	10
Cherts	2	0	149	10
Black ground and shale ...	60	2	210	0

The bottom of the shaft is about 123 yards above tunnel-level, whereas Lewis Shaft, 217 yards deep, goes to tunnel-level.

Near the New Shaft the vein consists of a series of irregular flats and ramifications of ore in the cherts, often taking the form of curves and arches following similar irregularities in the cherts (*cf.* Beili-gwyn Lode, p. 125). The folding of some of these bands of cherts is doubtless the effect of original deposition (p. 38) ; but in other cases it may be due to the faulted condition of the ground. Farther east, at lower levels, the vein occurs as stringers, stockworks, and vertical plates a few feet wide up to 9 or 10 feet in height, thinning off above and below. Farther eastward the ore occurs in a regular but complex vein, a stope examined in 1919 showing over 1 foot of solid ore. On the average the width of the vein is about 5 feet, its maximum width with branches being about 20 feet (Fig. 20).

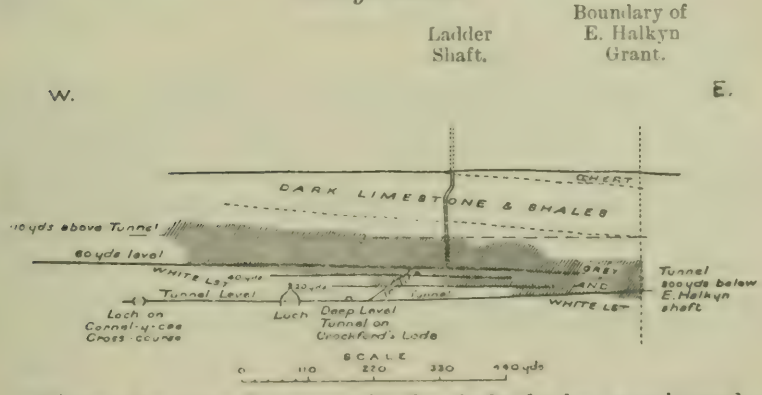
At the western end the chief ores were galena and cerussite, silver averaging about 4 ounces per ton. Towards the east centre, blende and calamine occur with galena, whilst cerussite was found in the cross-course to the south. Silver here averages 7 ounces per ton. At the extreme eastern end, near tunnel-level, blende occurs, but galena is absent. There was a trace of copper in the form of malachite in the roof of the 60-yard level.

The vein descends with the Cherts below tunnel-level, but no pumping is done in this mine. Some 200 tons of ore a month have been raised from this lode since 1911.

The Great Halkyn Lode.—At a point 970 yards south of the Lewis Shaft the Deep Level intersected a well-defined east-and-west fault or lode with a downthrow south, and containing blende and galena. At the surface the fault throws the Cefn-y-fedw Sandstone and Chert (p. 38) of Moel-y-gaer against the Limestone. The lode used to be referred to as the Bryn-gwiog Lode, because it was supposed to be the same lode as the true Bryn-gwiog Lode west of the Nant-figillt Fault. It is now recognised, however, that there is no sound reason for this correlation; moreover, the two lodes throw in opposite directions.

In the tunnel at more than 200 yards depth (225 yards below the top of the Ladder Shaft) both walls of the fault consist of limestone, and the majority of the levels in the mine are in grey or white limestone. On the north side of the fault the dip of the beds eastward is fairly normal, but on the south they roll slightly in conformity with the Wern-y-gaer dome and the Rhosesmor anticline. The hanging wall is of grit in the higher part of the western end of the mine, as might be expected; towards the centre of the mine it is of white limestone, and at the eastern end, at the top of the 60-yard level, it is of black limestone. This is at the northern end of the Rhosesmor anticline, which would cause the base of the Cefn-y-fedw Sandstone to be higher at this point than it is farther west.

FIG. 21.—*Section of Great Halkyn or 'Bryn-gwiog' Vein, Halkyn Mines.*



Where the tunnel crosses it the lode hades southward at about 27 degrees from the vertical. Towards the eastern end it underlies north for some distance between the 60-yard level (above tunnel) and the tunnel, but this is unusual. At the eastern end, however, the vein becomes complex and splits into branches, some of which dip northward. Two of the main branches are worked by the East Halkyn Mining Company.

A driving was made westward from the Halkyn Tunnel along the lode as far as the Cornel-y-cae cross-course (p. 128). Two fairly large lochs were driven through, the first, 70 yards west of the tunnel, measuring about 32 yards long by 25 yards high (Fig. 21, p. 131); the second, or Cornel-y-cae, was 24 yards long from north to south. Little ore was found. The tunnel-level was also driven eastward along the lode. The productive part of the lode was first struck by driving an incline up the fault eastward from tunnel-level. The incline struck lead richly and the mine was rapidly developed. From the 60-yard level a ladder-shaft leads to the surface. The 60-yard level was carried westward to the Cornel-y-cae cross-course and some little distance beyond it, but was not successful in finding much ore. At the cross-course the level was diverted southward for about 15 yards. Eastward the ore-bearing ground descends below tunnel-level, which is 200 yards below the East Halkyn Shaft. The lowest depth at which the ore is worked in East Halkyn Mine is 240 yards below the shaft top, where it occurs in the White Limestone.

The maximum thickness of the vein is from 20 to 30 feet, with 6 to 9 feet of galena, the remainder being blende, calcite, limestone, and chert-fragments. There is no quartz spar.

Blende occurs throughout the vein from top to bottom, but galena preponderates over blende in the centre; at the bottom blende occurs in scarcely payable quantities. A little barytes is found at the western end of the vein, where a quantity of fluorspar also occurs in bunches at the top and at Crockford's level.

In 1900 the concentrates gave 83·5 per cent. of lead with 6 ounces of silver per ton, and 54 per cent. of zinc; in 1918 they yielded 82·5 per cent. of lead with $6\frac{3}{4}$ ounces of silver per ton, and 57 per cent. of zinc.

The output of galena from 1883 to 1918 was 76,693 tons, with a value of £703,483, the average annual production being 2,130·36 tons at £9 3*s.* 5*d.* per ton. During the same period the output of blende was 22,657 tons with a value of £147,366, the average annual production being 629·36 tons at £6 10*s.* 1*d.* a ton. Over 100,000 tons of galena and blende have been raised to date. Of this amount about 10,000 tons came from the New Pant-y-gôf Lode. The present (1919) output of this lode is 40 tons of galena and 50 tons of blende per month.

Mining and Treatment.

In the Pant-y-gôf Lode mining is conducted by the usual methods; a large amount of ore is got with the pick, but shots also are necessary. The new shaft is fitted with ladders as well as a cage, and it is possible to traverse the whole vein from top to bottom by ladders, inclines and levels. The bearing-ground

measures about 500 yards on the horizontal. The ore is now lowered to tunnel-level and raised to the surface at the Lewis Shaft.

The 85-yard level has been driven eastwards through the overlying shale into the Cefn-y-fedw Sandstone, and it is hoped to explore the sandstone at some future date. From the 140-yard level at the foot of the New Shaft a cross-cut with a meandering course was pushed south-south-eastward in the Cherts for a distance (as the crow flies) of 660 yards, with the intention of picking up the Great Halkyn Lode, but fell short of its objective.

In both mines levels are calculated in yards above tunnel-level, and all the workings are above this level, which unwaters the mine.

In the Great Halkyn Lode the vein has been stoped up to an average height of about 110 yards above the tunnel, but the levels are higher at the western end than at the eastern end, in accordance with the eastward shoot of the ore-body. The bearing-ground covers a horizontal distance of 800 yards in this mine, and a further 280 yards in East Halkyn Mine. The ore is removed by the tunnel-level and the Halkyn Tunnel and raised at the Lewis Shaft. The ladder-shaft, from the 60-yard level to the surface, is used chiefly for access and for ventilation.

The ores are dealt with at a concentration-plant near the Lewis Shaft. At the old building the ore is crushed with manganese-steel jaws to fragments of 8 mm. size or less, this being the size of the largest jig-mesh. It is then sorted by trommels and water-classifiers and passed into jigs with 8, 5½, 3½, 2½, 2 and 1½ mm. meshes. Elevator-buckets used for re-crushing are also of manganese-steel.

At the new building the grades obtained from the jigs are mixed and re-crushed and put through manganese-steel rollers and again through trommels and water-classifiers. The coarsest trommels have a 3 mm. mesh, other sizes being 2 and 1½ mm. Jigs are of 3, 2 and 1½ mm. mesh. In the jigs the first box is nearly pure galena, the second galena and blende, the third blende and waste, and the last blende and a higher proportion of waste. Operations are repeated time after time.

Further separation of slimes is effected by round buddles or flat buddles and by 'dollies.' The very finest material is treated at Wilfley vanning-tables.

The 8 mm. sieve galena from the Pant-y-gôf Lode is sent to the Potteries for glazing; this contains no fluorspar, whereas some is likely to remain unseparated in the case of ore from the Halkyn Lode. Smaller mixed grades from both lodes are sent to Purex, Ltd., of Greenford, Middlesex, for smelting. Galena was formerly sent to Messrs. Walkers, Parker & Co., of Bagillt, and to Messrs. Quirk, Barton and Burns, of St. Helens.

The blende from the Pant-y-gôf and Halkyn Lodes is of high quality (*see* assays, p. 18). Blende has been sold to Messrs. Vivian & Co.; the Swansea Vale Spelter Co.; Messrs. Higginbottom & Co.; and Messrs. Dillwyn & Co.

It is possible that in future the tailings or residues may be treated by some such process as that adopted by the Electrical Metallurgical Co., Ltd., which has taken over the acid-section of the plant of the Explosives Department at Queensferry. By this process spelter is to be produced from soluble chlorides obtained by the action of chlorine. Silver and lead also would be recovered, and the by-products would include sulphuric acid, caustic soda, and bleaching-powder.

Since the amount of fluorspar present precludes the complete separation of the blende by the processes employed at the mine, the percentage of blende in the tailings is high (*see* assays, p. 19). Spelter-makers require a minimum of fluorspar. The slimes contain a higher proportion of zinc than the tailings, and command a higher price. It is estimated that there are 200,000 tons of residues available.

An oil-flotation process of separation has been mooted, but not yet adopted.

East Halkyn Mine.

East Halkyn Mining Co., Ltd., Old Bank Buildings, Chester.

Batter's or Bather's Shaft, situated at Rhosesmor, about 2 miles S. of Halkyn.

Maps.—One-inch Old Series Geological, 79 S.E.; New Series Ordnance, 108; six-inch, Flintshire 9 S.E. (Halkyn Tunnel, 9 S.W.).

Batter's Shaft	... Lat. 53° 12′ 20″.	Long. 3° 10′ 45″.
Incline Shaft	... Lat. 53° 12′ 53″.	Long. 3° 10′ 45″.

History.

An account of the old Rhosesmor Mine is given on p. 72. This mine was taken over by the present company from the Rhosesmor Mining Co. about the year 1901, at which date the lowest workings were 170 yards below Batter's Shaft. The Westminster Lode only was worked. A tunnel was driven at the 170-yard level northward towards the Great Halkyn Lode, which at that date was worked from an incline-shaft to the local tunnel-level. After driving nearly 600 yards, a new lode, Powell's, was discovered in 1903. Powell's Lode was connected by tunnel with the Great Halkyn Lode at a later stage.

Geology.

Rhosesmor is situated upon an anticline of Limestone, to the south-east of the Cefn-y-fedw Sandstone and Chert hill named

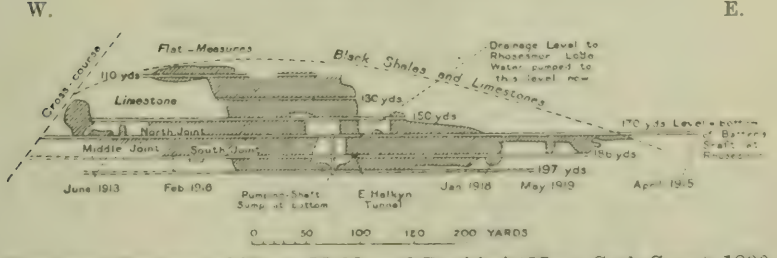
Moel-y-gaer. To the west of the Rhosesmor anticline another limestone-tract rises as an inlier through the Chert and Sandstone series at Wern-y-gaer.

The Rhosesmor branch of the Halkyn Deep Level Tunnel (Fig. 6, p. 71) strikes off south-eastward at a point about 470 yards south of the Great Halkyn Lode. At this point the tunnel is in limestone on the flanks of the Wern-y-gaer anticline. At about 50 yards in the direction of Rhosesmor it enters the overlying black shales and bastard limestones. A lode (the principal water-feeder) bearing S. 67° W. was struck at 396 yards distance from the junction of the tunnels, and thereafter the Rhosesmor branch-tunnel is mostly in limestone as far as Rhosesmor. The water-lode has not been followed up. A second lode was cut at 560 yards from the junction, and a third—the Westminster Lode—at 750 yards from the junction, or approximately 60 yards from the Rhosesmor Lode. Levels in all the lodes are measured from the surface.

The Westminster (Grosvenor) Lode.—This proved to be unproductive at tunnel-level (p. 73). The vein was poor at the 140-yard level, the ore raised coming from a higher horizon. Dixon's Lode branches off the Westminster from the east side.

Powell's Lode.—This lode, like that of Rhosesmor (p. 72), occurs in an anticline of limestone, overlain by the dark limestones and shales that occur beneath the Cefn-y-fedw Sandstone Series, but the general hade of the lode is in the opposite direction, namely, to the south. The lode trends slightly south of east, and the bearing-ground is approximately 680 yards long at the 170-yard level (Fig. 22, below). Both eastward and westward the bearing-ground is cut off by shales and dark limestone.

FIG. 22.—*Section of Powell's Lode, East Halkyn (Rhosesmor) Mines.*



Compare 'Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, Fig. 20, p. 181.

The tunnel, which is entirely in limestone from Rhosesmor, strikes the lode almost in the centre of its length. West of this point a joint springs off to the south—the South Joint—and farther west another—the Middle Joint—springs off from the north side of the South Joint. These joints both hade to the south. The western veins are inclined at about 20 degrees

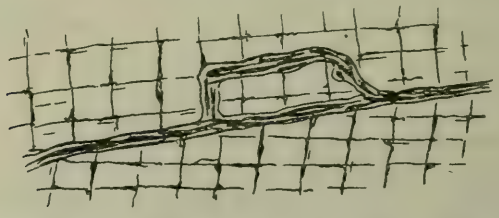
from the vertical, but east of the tunnel the lode is nearly, but never actually, vertical. Along the course of the lode, limestone is usually thrown against limestone; but towards the east blue limestone is said to come in on the north side, and some chert occurs in the vein. At the same point white limestone occurs on the south side. It is possible, therefore, that the fault changes its throw at the eastern end. On the north side of the North Branch the measures are flatter than on the south, where the dip is to the south-east.

At the western end of the mine a cross-course, bearing approximately N. 20° W. with downthrow west, brings in the dark limestone and shales (Fig. 22, p. 135). This cross-course is probably the underground representation of a fault, with the same hade and nearly the same trend, visible in an old quarry on the south-east flank of Moel-y-gaer.

A one-yard fault also, trending east-and-west with downthrow south at 45 degrees, was detected in this quarry in 1919. This may be the surface-position of part of Powell's Lode.

In the North Branch, or main vein, the ore occurs in bunches, one example, totalling 12 yards wide and only a few yards in length, consisting of mixed galena, blende, calc-spar, sand, and clay. These bunches nip out above and below; bunches occur again below the tunnel at the 186- and 197-yard levels. Occasionally the vein nips out to 1 inch or less in width. Flats occur in the grey limestone on the north side of the vein for a distance of 10 yards or so, apparently following joints in the limestone (Fig. 23, below). The vein was stoped up to the

FIG. 23.—*Plan (diagrammatic) showing flats on north side of Powell's Lode.*



110-yard level on the west, where the crown of the anticline is situated. It shoots gently eastward, the highest level east of the tunnel being the 155-yard.

The vein has been most prolific in the central parts of the anticline. At the extreme east, however, it has not as yet been explored fully, and, though the tunnel-level has been pushed out into black limestones, no ore has yet been found. The cherts or sandstones are being sought.

On the Middle Joint the ore is bunchy, but more continuous on the whole than that in the North Branch; the average thickness of the ore is 10 to 12 inches.

On the South Joint the ore averages 7 to 8 inches, and is not so bunchy as on the North Joint.

Galena and blende occur in about the same proportions throughout, namely 4 to 1. At the eastern end of the mine the galena takes the form termed 'steel-ore,' which is less well crystallised, more dense and tougher than the more normal 'brittle ore' at the west end. It contains from 6 to 8 ounces of silver per ton, whereas the brittle ore contains only 3 ounces per ton. The galena contains from 83–84 per cent. of lead; the blende from 51 to 53 (rarely 55) per cent. of zinc.

A little calamine has been found at the western end of the mine. Fluorspar occurs chiefly at the western end, but a little occurs in the east also. Barytes and manganese are absent. The spar filling the vein is mostly calcite. Some lochs are filled with clay.

Reserves lie chiefly below the 197-fm. level. Recent outputs are as follows:—

Output for 1913: galena, 1,893¼ tons; blende, 111 tons 12 cwt.
„ „ 1918: „ 1,153 „ „ 181 „ 17 „

Between 1903 and 1913 about 24,723 tons of galena averaging 80·9 per cent. lead and 2,168 tons of blende averaging 46·7 per cent. zinc have been obtained.

The Great Halkyn Lode.—The ore worked on this lode in the East Halkyn Grant is got from two veins that appear to lie slightly south of the main vein worked by the Halkyn Mining Co. (p. 131).

The plans of the workings on opposite sides of the boundary show no signs of a heave, hence the veins are probably fliers off the main vein, which appeared to be splitting into branches in this direction (p. 131). The two branches worked lie about 350 yards north of Powell's Lode; they hade southward and come together at the western boundary. At the 180-yard level the North Branch descends vertically to the drainage-level at 200 yards, below which it returns to its former underlie. Ore has been worked chiefly at the 200, 220, and 240-yard levels. At the 220-yard level the horizontal length of the North Branch is about 250 yards, its eastern end being cut off by a cross-course bringing in 'metal.' These veins were more profitable than Powell's Lode.

Reserves, which are stated to be considerable, lie below water-level. In 1910, the last year of working, the output was 414 tons of galena and 75 tons of blende.

Between 1891 and 1910 about 13,101 tons of galena averaging 82·95 per cent. lead, and 4,476 tons of blende, averaging 53 per cent. zinc, were obtained.

Mining.

The usual methods of mining are employed From the 170-yard level in Powell's Lode, a sump was put down for

30 yards and a pump installed to unwater the 186 and 197-yard levels, the water being lifted to the 170-yard tunnel-level (Rhosesmor Branch). In wet weather 4,000 gallons a minute are pumped, the usual amount being about 3,500 gallons. The pump, which is electrically driven, was installed in 1911, and was expected to be in use for a short time only, namely, until the sea-level tunnel was made.

The branch of the Halkyn Tunnel that traverses the Great Halkyn Lode at 200 yards and links up with Powell's Lode, is at 186 yards depth at Powell's Lode (Fig. 22, p. 135). At the Great Halkyn Lode water was pumped from the 240-yard level to the 200-yard drainage-level and travelled thence westward to the main Halkyn Tunnel. The mine was closed owing to the difficulty of coping with the water.

At this lode, before the mine was connected with Powell's Lode, the ore was raised by the Incline Shaft. From that date to 1910 it was brought underground to Rhosesmor and raised at Batter's Shaft with the ore from Powell's Lode.

A dressing-plant, similar to that at the Halkyn Mines, is situated near Batter's Shaft.

North Hendre Mine (Rhydymwyn).

North Hendre Lead Mining Co., Ltd., Hendre, Mold.

Situated about a mile N.W. of Rhydymwyn Station (Mold and Denbigh Railway), 3 miles N.W. of Mold.

Maps.—One-inch Old Series Geological, 79 S.E.; New Series Ordnance, 108; six-inch, Flintshire 9 S.W.

Engine Shaft	...	Lat. 53° 12′ 3″.	Long. 3° 12′ 2″.
Olwyn-côch Shaft	...	Lat. 53° 12′ 4″.	Long. 3° 11′ 46″.
Taylor's Shaft	...	Lat. 53° 12′ 4″.	Long. 3° 11′ 28″.

Other shafts: Mostyn (Old Engine) Shaft, 100 yards W.S.W. of Engine Shaft; Victoria Shaft, 200 yards W. of Mostyn Shaft.

Old North Hendre Mine: Bromley's Shaft, Engine Shaft and No. 2 Shaft (pp. 75, 76).

History.

The Hendre Lode (p. 77) had been worked at outcrop prior to 1867, and also in depth from the Fron, Victoria, Mostyn and Old Engine Shafts. A part of the ore was got from above the present drainage-level in the upper part of the vein; but most came from the lower part, below the 'second shale' (p. 141). Messrs. Cobden and Bright raised 400 tons a month for eight consecutive years. They failed to carry on owing to water-difficulties, although about 2,000 gallons of water a minute were pumped.

The present company was formed in 1867 and worked the flats of the Old North Mine only. In 1894 Olwyn-côch Shaft

was sunk to get into touch with the Hendre Lode, which had been worked extensively in former years. Lead was struck in 1895 at about 115 yards from the surface; this was the South Lode, an offshoot from or heave of the Hendre Lode. The lower workings of the mine became flooded in 1898. The mine produced again in 1899, and was again flooded in 1901. It was unwatered in 1906, when a dam was fixed and a pump installed below. In that year Taylor's Shaft, put down by another company, was bought, and the mines worked until 1908, when they were again flooded. They have now been flooded 11 years. Since 1917 preparations have been made to unwater and open out again, but the scheme is in abeyance (p. 25).

Geology.

The higher part of the Limestone Series, containing beds of sandstone, shale, and dark limestones, overlying the White Limestones, dips eastward at about 10 degrees beneath the Chert Series and the Lower Coal Measure shales of Nant-figillt. The strata are breached by a deep valley running generally east-and-west and carrying the Mold and Denbigh Railway. The ore-bodies that have been worked by this company are: (1) the flats in the old North Hendre Mine (p. 76); (2) the Hendre Lode and the South Lode.

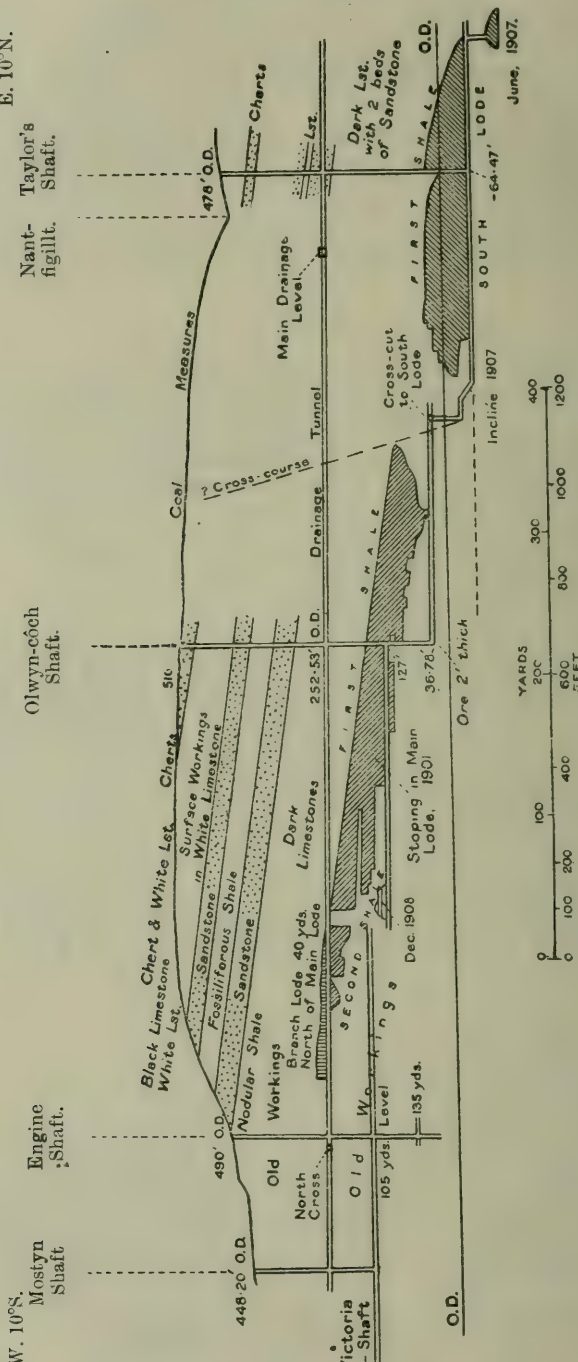
Hendre Lode (*Coed-Hendre Vein*).—This vein (Fig. 24, p. 140) runs a little north of east on the northern side of the Hendre Valley. It underlies south and throws the strata down in that direction about 1½ feet, as may be seen in the little cliff near the engine-house, where the walls of the vein show the striations and flutings of slickenside in a nearly horizontal direction.[1]

The Hendre Lode is separated from the Tyddyn-y-barcud Vein by a cross-course, 22 inches wide, to the east of which the ore occurred in numerous shoots or runs following the gentle dip of the beds eastward. Some of these were worked from old shafts from west to east, viz.:—Fron Shaft, 75 yards deep; Victoria Shaft, 75 yards deep; Mostyn (Engine) Shaft, 105 yards deep, 200 yards farther east in the valley-bottom; and the Old Engine Shaft, over 135 yards deep, at the foot of the escarpment. Farther east a series of shallow trenches and shafts on the top of the escarpment mark the course of the vein until it is lost in the Lower Coal Measure shales.

At Fron Shaft a shoot of ore about 75 feet in vertical depth occurred near the surface and dipped gently eastward past Victoria Shaft and Mostyn Shaft, where its vertical height increased to about 150 feet, the ore lying chiefly between the 50-yard and 105-yard levels.[2] At the Old Engine Shaft this shoot was split into two by a stratum of black limestone, the

[1] 'Geology of Flint, Mold, and Ruthin' (*Mem. Geol. Surv.*), 1890, p. 182.
[2] Home Office plans.

FIG. 24.—*Section of the Hendre or Coed-Hendre Lode, Hendre Mine.*



ore occurring in two beds of white limestone, in which the lower run of ore descended below the 105-yard level. In 1908 ore was stoped beneath this end of the run, under the so-called second shale, at a point about midway between the Old Engine Shaft and the Olwyn-côch Shaft (Fig. 24, p. 140).

That part of the Main Hendre Lode worked recently occurs chiefly between two beds of shale known as the 'first' and 'second' shales, respectively 10 feet and 10 to 13 feet in thickness. This shoot of ore failed at a point 400 yards east of the Olwyn-côch Shaft. It was partly worked between 1899 and 1901 (Fig. 24).

A branch lode with a shoot of ore, found 40 yards north of the main lode, was worked in 1900, just above the level of the drainage-tunnel. The ore lies beneath the 'first shale.'

A cross-cut northward from Taylor's Shaft failed to find ore on the line of the main lode, but a vein—the South Lode—was found 4 yards south of the foot of the shaft. This run of ore lies 30 yards south of the shaft at drainage-level (Fig. 24, p. 140), and therefore hades to the north. The ore may occur in the same fault-plane as the main lode, shifted southward and tilted by a cross-course. After the main lode dies out, the south lode picks up about 150 feet farther east. The cross-cut connecting the north lode with the winzes and incline from the south lode is about 60 yards in length, at 36·78 feet above O.D.

South Lode.—This is approximately 680 feet in length and shoots eastwards. It has been worked down to — 64·47 feet O.D., its greatest vertical thickness being 100 feet. At the extreme eastern end a shaft was put down in 1907 for about 70 yards from the — 64·47-foot level. As a cross-cut southward found good ore at this greater depth, the vein may be shifted southward at this point by a cross-course.

The main vein averages about 25 yards in vertical depth and from 18 inches to 7 feet in width. 'Horses' occur occasionally in the vein, when it may be as much as 22 feet wide. It contained galena and blende in the proportions of about 9 to 1, the two minerals being fairly evenly distributed; but the blende increased in proportion near the bottom of the lode. Silver amounted to 4 ounces per ton of galena. The gangue consisted chiefly of limestone, spar and quartz. The black limestones carry little or no lead.

There are fairly large reserves in depth, but the whole district is waterlogged up to the main drainage-level. The output of lead-ore for 1907 was valued at £24,424; but 1908, with 2,099·5 tons, was the most recent record year. In 1897 the output reached 3,850 tons, valued at £32,248. From 1895 to 1909 inclusive, 20,810 tons of lead-ore were raised, with a percentage of 84 of lead. In the same period 2,811 tons of blende, averaging 56·3 of zinc, were gotten.

The section of Taylor's Shaft is as follows:—

Taylor's Shaft, Hendre Mines.

Top of Shaft 478 feet above O.D.

	Thickness.		Depth.	
	Feet.	Inches.	Feet.	Inches
Sand and gravel ... ... Coal Measure shale (60–70 feet). Chert, fossiliferous limestone, shale and sandstone	190	0	190	0
Limestone	4	8	194	8
Sandstone	32	2	226	10
Drainage-level at 224 feet, approx.				
Limestone	3	7	230	5
Sandstone	11	3	241	8
Dark limestone with beds of sandstone, each several feet thick	207	0	448	8
White limestone	111	0	559	8
Lowest level at 542·47 feet.				

Mining.

The usual mining methods have been employed, with the latest types of compressors and rock-drills. The mine is worked entirely from shafts. The shale makes a bad roof; but the chief obstacle to working is water. Deeper drainage, such as would be secured by the Milwr Tunnel, is urgently needed, and would drain the mine to a depth of 36·78 feet above O.D.; pumping, however, would still be necessary. The situation is unfortunate in that, owing to deep pumping, water from neighbouring mines has drained into the North Hendre Mine, and the workings have been subject to sudden inrushes of water from north-and-south cross-courses.

Before flooding, 11 years ago, 2,000 gallons of water per minute were pumped. A new scheme (p. 25), capable of dealing with 4,000 gallons per minute, has been initiated; this would unwater the mine to the -- 64·47-foot O.D. level, and would drain neighbouring mines also.

The present drainage-level, connected with the Halkyn Tunnel, is 60 yards below the bottom of the Hendre Valley. The tunnel itself passes a few yards west of Taylor's Shaft on its way southward to the Llyn-y-pandy Lode.

As this tunnel was extended from the Halkyn Mines to Rhydymwyn, white limestone eventually gave place to dark limestone and shale, possibly in crossing the Nant-figillt Fault. It lies entirely below Cefn-y-fedw Sandstone and Coal Measures. Of late years, so heavy have pumping costs become, the Drainage Company has been obliged to subsidize some of the mines by lowering the royalties charged per ton of ore raised.

In addition to preparing Taylor's Shaft and the mine for the new unwatering scheme, some prospecting has been done since the early part of 1917. A cross-cut was made southward from

a bend in the drainage-level west of Olwyn-côch Shaft with the object of cutting the Tyddyn-y-barcud Vein (p. 77), and also the New Garreg-boeth Vein (p. 77), under the 'first shale.' The first of these veins was not found, but what may be a branch of, or a joint in, the New Garreg-boeth Vein was cut about 165 yards south of the drainage-level. The cross-cut was continued about 70 yards farther south, but without success.

The ore was treated at the works by a washing and concentrating plant, at which 95 per cent. of the ore was separated. The dumps are now sold for gravel. The separated ore was sent chiefly to Messrs. Walkers, Parker & Co., Bagillt, and to St. Helens. Some went to Messrs. Dillwyn in South Wales. There is every facility for transport, the mine being connected by short sidings with the Mold and Denbigh Railway.

Garreg-Boeth Lode (East).

South Halkyn and Rhydymwyn Mining Co. Ltd., Halkyn, Holywell.

Situated about 5 furlongs W.N.W of Rhydymwyn Station (Mold and Denbigh Railway).

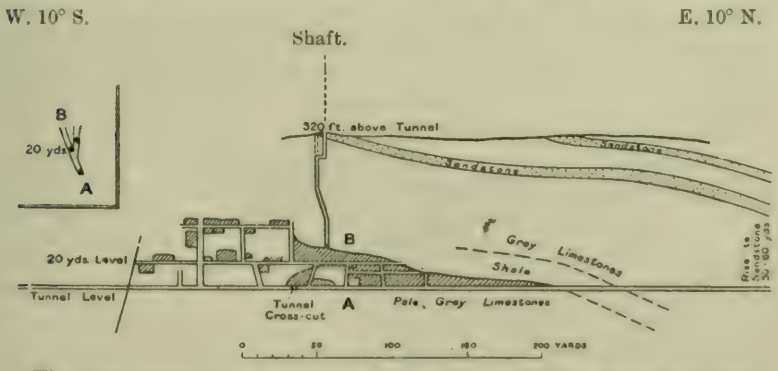
Maps.—One-inch Old Series Geological, 79 S.E.; New Series Ordnance, 108; six-inch Geological, Flintshire 9 S.W.

Ladder Shaft: Lat. 53° 11′ 44″. Long. 3° 12′ 6″.

History.

The Old Garreg-boeth Lode was worked with some success 70 or 80 years ago (p. 78), but it was not until the Halkyn Drainage Tunnel reached the property that attention was

Fig. 25.—*Section of Garreg-boeth Lode, South Halkyn Mine.*



The inset shows the junction of the main and branch lodes on the line A–B.

directed to the productive eastern extension of the lode beyond what is supposed to be the Nant-Alyn cross-course (p. 78). The Halkyn Tunnel was carried southward from near Taylor's

Shaft (North Hendre Mine) to the West Iron Shaft on the Bryncelyn Lode, a distance of 1,370 yards. In 1908 a branch, at tunnel-level, starting a little west of Taylor's Shaft on the Bryn-celyn Lode, was driven north-north-westward and cut what is presumably the eastward extension of the Old Garreg-boeth Lode at a point a few yards west of the Ladder Shaft.

Geology.

The new vein lies almost in line with the old lode. About 325 feet to the west of the tunnel cross-cut (Fig. 25, p. 143) it appears to be intersected by a cross-course (probably the northward continuation of the Bryn-celyn cross-course), beyond which the lode, consisting of about $3\frac{1}{2}$ feet of calc-spar, appears to be barren up to the supposed Nant-Alyn cross-course. In this tract the measures form a syncline with north-and-south axis and the old lode hades southward. The new productive vein hades northward and consists of two branches, north and south, that unite near the shaft at about 20 yards above tunnel-level.

The new lode has an average width of 2 feet, but swells out occasionally to 6 feet, comprising calc-spar in which several ribs of ore have an aggregate thickness of 3 feet. It occurs in a pale-grey limestone and shoots eastward beneath a thick bed of shale, the top of the ore-shoot crossing tunnel-level about 525 feet east of the tunnel cross-cut. The shale is overlain by grey limestones through which the tunnel-level in the lode has been driven eastward for a total distance of 950 feet from the tunnel cross-cut. At this point a rise had been put up to a bed of sandstone 50 to 60 yards above tunnel-level.

The vein is virtually intact below tunnel-level, and it is expected that a yield of 200 tons a month could be obtained if deeper drainage could be secured, this average having been obtained in 1910 when there was fair scope for working. Unfortunately the branch tunnel intersected the lode at a depth of not more than 320 feet from the surface, thus securing the drainage of the bearing-measures to no greater depth than 45 yards at the maximum (Fig. 25).

The output in 1909 was 1,671 tons; in 1910 it was 2,456 tons. In 1911 it fell to 698 tons on exhaustion of the available ore-bearing ground above tunnel-level. During 1909 and 1910 royalties amounting to £6,191 were paid to the Drainage Company.

Mining.

The shaft is an irregular ladder-way, originally 20 yards deep, and communicates with a rise put up from the tunnel-level. The ore won was raised at Davey's Shaft on the Bryncelyn Vein (p. 81) and conveyed by a self-acting inclined tramroad to dressing-floors at the south side of the old foundry at

Rhydymwyn, where, since it took the form chiefly of lumps, there was no difficulty in concentrating it cheaply by hand.

About 125 yards south of the Garreg-boeth Lode the above-mentioned tunnel-level cross-cut between the Bryn-celyn and Garreg-boeth Lodes crossed a lode, hading south, but nearly vertical. This is named the Pydew Lode, from its supposed (but possibly unreal) connexion with the Joint-y-pydew, which occurs farther south-west (p. 78).

Ore was found on this lode below water-level in quantities said to be payable.

About 230 yards farther south a short offset westward, from tunnel-level, discovered a cross-course trending more or less parallel to the tunnel. This is thought to be the Bryn-celyn cross-course, which heaves the Bryn-celyn Lode (p. 80), and, as above stated, appears to affect the Garreg-boeth Lode also. Farther south, near the Bryn-celyn Lode, the tunnel-level cross-cut deviates westward from a straight line for a space, in order to follow a small cross-course. Development of these lodes awaits the realization of the proposed deep-drainage scheme.

APPENDIX.

Plans of Abandoned Mines.

Plans of some of the abandoned lead and zinc mines referred to in this volume (and of others not mentioned therein) are preserved at the Home Office. The following list is assembled from the Official Blue Book: 'List of the Plans of Abandoned Mines deposited in the Home Office,' 1920. Plans with the letter R prefixed to the number, and also those of all mines that had been abandoned for more than ten years by 31st December 1919, are open to inspection.

The last column in the following list gives the pages of the present volume on which the mine is mentioned.

Register Number	*Name of Mine*	*Post Town*	*Ores Worked*	*Date when received*	*Page in Text*
		Flintshire.			
R. 301	Bodelwyddan ...	Bodelwyddan	Lead	1857	33
R. 316	Cala	Halkyn	,,	—	—
R. 205	Cat Hole	Mold	,,	—	90
5026	,, ...	,,	Lead and zinc	3.6.1907	,,
5024	Cefn-mawr ...	,,	,,	,,	89
R. 284	Deep Level ...	Halkyn	Lead	1849	70
R. 51	Fawnog	Mold	,,	—	89
R. 27	Garreg-boeth ...	Holywell	,,	—	77
3082	Glyndwr	Mold	,,	2.5.1894	93
R. 161	Gwern-y-mynydd..	,,	,,	—	90
5027	,, ,,	,,	Lead and zinc	3.6.1907	,,
R. 201	Hendre	,,	Lead	—	76, 138
R. 303	Heward	Holywell	,,	—	125
R. 63	Holywell		,,	—	—
R. 51	Jamaica	Mold	,,	—	94
R. 183	Lloc	Whitford	,,	—	56
R. 194	Llyn-y-pandy ...	Mold	,,	—	81
1487	Pant-du, East ...	,,	,,	16.4.1883	97
R. 87	Pantybuarth ...	,,	,,	—	86
5025	,, ...	,,	Lead and blende	3.6.1907	,,
R. 51	Pantygo and Panty-ffrith.		Lead	—	68
R. 157	Penybryn and Hafod-wen.	Holywell	,,	—	58
R. 121	Penyfron and Rhydymwyn.	Mold	,,	—	82
4631	Plantation ...	Holywell	Lead and zinc	26.7.1904	—
5706	Talacre	Prestatyn	,,	1.12.1911	42
1698	Talargoch... ...	Rhyl	Lead	28.1.1885	38
R. 138	,, ...	,,	,,	—	,,
R. 193	Trelogan	Holywell	,,	—	46
5620	,, ...	Mostyn	Lead and zinc	20.5.1911	,,
6155	Wallside	Holywell	,,	10.6.1914	—
R. 284	Westminster ...	,,	Lead	1849	799

Register Number	*Name of Mine*	*Post Town*	*Ores Worked*	*Date when received*	*Page in Text*
		DENBIGHSHIRE.			
5028	Lisburne	Mold	Lead and blende	1.2.1907	—
5044	Llanfair	Abergele	Lead, zinc, and copper	12.3.1907	—
5029	Maes-y-faen ...	Mold	Lead and zinc	1.2.1907	—
R. 139	„ ...	„	Lead	1851–1872	—
R. 146	Minera	Minera	„	—	103
6337	„	Wrexham	Lead and zinc	21.7.1915	„
3241	„ New ...	„	„	15.3.1895	105

INDEX.

Abbey Mills boring, 17.
Aberdine, 93.
'Aberdo' Limestone, 5, 36, 45–48, 99, 101, 113.
Abergele, 1, 3, 4, 6, 11, 31, 32, 147.
Afon-gôch, 46; Fault, 46, 47; Vein, 47.
Afon-y-garth valley, 47.
Africa, West, ore exported to, 20.
Alderley Edge, 12.
Allsopp's String, 54.
Alltgymbyd, 101.
Alteration of ores, secondary, 14.
Alyn, River, 29, 79–81, 85, 86, 90, 92, 95, 97, 98, 100.
America (House), 94.
——— Vein, 58.
Analyses and assays, 18–21.
Anglesite, 8, 11, 62.
Aqueduct Grit, 5, 7, 103.
Argentiferous galena, 8, 13, 15, 49.
Ashton Mine, 59.
Assays and analyses, 18–21.
Axton, 47; Fault, 45–47; Mine, 45, 46; Vein, 45.

Bagillt, 26, 89, 118, 125, 133, 143; smelting-works at, 3.
Bala Fault, 4, 7, 8, 11, 23, 29, 36, 37, 101–103, 105, 107, 115; Llanelidan Branch, 7, 8, 13, 23, 101, 102.
Barytes, 8, 9, 11, 41, 75, 78, 99, 101, 109, 132, 137.
Basement - Beds — Carboniferous Limestone Series, 5, 7, 30, 31, 36, 103; Silurian fossils in, 30.
Basingwerk Abbey, 2.
Bastard chert, 51.
Bean Vein, 115.
'Bearing-chert,' 9.
'Bearing-spar,' 9.
Beili-gwyn Lode or Vein, 28, 57–60, 119, 124, 125 (section), 126.
Belgrave Mine, 98; Vein, 16, 17, 98.
Bellan adit, 85.
'Bellies' of ore, 48.
Berth-ddu, 70.
Berthen Farm, 61.
Bettisfield Colliery, 118.
Berwyn Hills, 5, 7.
'Big Duke' spring, 53.
Billins, 65, 66.
Bituminous limestones, 37.
'Blacking,' 11, 77, 99.
'Black Jack,' 8, 82.
Black Limestone, 5, 36, 37. *See also* details of Mines.
'Blackstone,' 121, 130
Blaen-y-nant Lode or Vein, 17, 98.
Bleaching-powder, 134.
Blende, 8; analyses of, 18, 19, 20, distribution of, 8–13; in discs, 97.
Blende Sump, 126.
'Blue ore,' 82.
Boat-level, 49, 50, 52, 53.
Bodelwyddan, 33, 146; Hall, 33, 35; Mine, 33, 34 (output), 35, 146.
Bôd-Idris, 11; Fault, 101; Mine, 101; Vein, 21.
Bog-Celyn Mine, 54, 55.
Bog Mines, 28, 99, 100.
—— Vein, 16, 17.
Bolly's Lode, 66.
Boring, Abbey Mills, 17.
Boulder-clay. *See* details of Mines.
Boulton & Watt, Messrs., 82.
Boutflour Vein, 49.
Brammock's Vein, 51–53.
Bramwell's Vein, 66.
Branch Vein (to Old Holloway Vein), 55.
Brass-making by Romans, 2.
'Brittle ore,' 10, 137.
Brocnallt (Brocknallt), 50, 51; cross-course, 53.
Bron-Holloway, 51–53.
Brunner, Mond & Co., Messrs., 87, 88, 92, 96; zinc-process, 88.
Bryn (Trelogan), 47.
—— Vein, 48.
Bryn-celyn cross-course, 80, 81, 83–85, 87, 144, 145.
Bryn-celyn Lode or Vein, 3, 16, 21, 25, 26, 79–81, 84, 144, 145.
———— Mine, 82.
Bryn-cloddiau, 61.
Bryn-côch, 85; Vein, 75.
Brynford, 52, 53, 59, 61, 63; Hall, 57, 58.
Bryn-gwiog, 11, 73; Lode or Vein, 21, 28, 75, 128, 131; Mine, 14, 16, 25, 73.
———— Mines, Ltd., 127.
Bryn-gwyn, 65, 92–94; Farm, 94.
———— Run, 94.
Bryn-haidd Vein, 99.
Bryn-hyfryd, 87.

Bryniau-cochion, 30; cross-course, 59.
Bryn-moel, 23. 70.
Bryn Parade Vein, 68.
Bryn-y-castell, 87.
Bryn-y-gaseg, 61.
Bryn-yr-orsedd, 98.
Buckland, W., 43.
Buckley Mountain, lead-smelting works, 82.
Buddles, 133.
Bunches of galena, 44, 118, 121, 136.
Busy Bee Vein, 107.
Butcher Vein, 48.
Bwlch-gwyn, 104, 115, 116; Church, 115; Mine, 115.
Bwlch-y-ddaufryn Mine, 16; Vein, 86.

Cadlas hîr, 50.
Caeau Farm, 126; Lode, 121, 126; Mine, 26, 63.
Cae-llwyd, 113.
Cae-llys Joint, 39.
Cae-pant sett, 107.
Cae'rgwaith Mines, 33.
Caetiau'r Odyn, 50.
Cala Mine, 146.
Calamine, 2, 8, 9, 11, 41, 43, 54, 61, 67, 75, 88, 92, 108, 116, 130, 137.
Calcite, 8, 32, 64–67, 77.
Calcium carbonate in spars, 9, 58, 59, 62.
——— fluoride, 18. *See also* Fluor-spar.
Calcoed Hall, 53.
——— Outlier, 49.
Calc-spar, stalagmitic, 32, 65.
——— with copper-pyrites 64, 66, 67, 77.
Caleb Bell cross-course, 27, 28, 58, 62–64, 66, 76, 78, 87; as feeder of St. Winifred's Well, 59.
California Lode or Vein, 43, 68–70.
Cambria Mine, 61.
Canal Level, 49.
Capel Saron, Brynford, 59.
Carboniferous Limestone, 4, 7; conditions for deposition of ore in, 12.
Carboniferous Limestone Series, 3–5, 36–38; 'Aberdo' Limestone, 5, 36, 45–48, 99, 101, 113; Basement-Beds, 5, 7, 30, 31, 36, 103; Black Limestone, 5, 36, 37; Lower Grey and Brown Limestone, 5, 7, 30, 31, 36, 37, 103; Sandy Limestone, 5, 36, 37, 103; Upper Grey Limestone, 5, 7, 30, 31, 36, 37, 103; White Limestone, 5, 7, 36, 37, 103. *See also* details of Mines.
Carboniferous Limestone Series, coal in, 37; drainage, 22, 23; zone of heaviest mineralization, 11; thickness, 4; Vale of Clwyd, 30, 31.
Carboniferous rocks, 4, 5.
——— shales, 103.
Carreg-y-frân, 41, 42.
Cascade, underground, 50.
Castell Cawr Hill, 31.
Catch Lode, 67, 69.
Cat Hole, 90; cross-course, 89, 90, 96; Lode or Vein, 17, 21, 28, 91, 96; Mine, 16, 68, 83, 90–92, 146.
Caulk, 8.
Caunter Lode, 114, 115.
Caverns, 50, 54, 59, 90; ore-filled, 76; subterranean, 108.
'Cawk,' 41.
Cefn Farm, 57.
Cefngo' Mines, 33.
Cefn-bychan, 87; Lode, 87.
Cefn-Cilcain Vein, 78.
Cefn-hîr, 96, 97.
Cefn-Kilken, 82.
Cefn-mawr, 89, 96; Hall, 90, 91; Mine, 146.
Cefnybedd Tunnel, 29.
Cefn-y-fedw Cherts, 5, 36, 37, 38; zone of heaviest mineralization in, 11. *See also* details of Mines.
Cefn-y-fedw Sandstone ('Millstone Grit') Series, 3, 5, 7, 36, 38; cherts in, 5; coal in, 91, 92; conditions for deposition of ore in, 12; drainage, 22, 23; shale in, 129, 133; thinning out of, 38.
Cefn-y-gist Mines and Vein, 114.
Cefn-y-maes, 107.
Cefn-yr-ogof Mine, 32.
Celyn Farm, 54.
Cement-stones, 63, 119.
Central Halkyn Mining Co., 69.
Cerrig-Heilyn, 42.
Cerussite, 8, 9, 11, 20, 84, 88, 130.
Chalcopyrite, 8, 109.
Chalybeate water, 45.
Chalybite, 113.
Chemical composition of rocks affecting deposition of ore, 12.
Charles I, 2.
Chert-breccia, 40, 43.
Cherts in Cefn-y-fedw Sandstone Series, 5, 9, 36–38.
Cherty limestone, 31, 37, 41.
Cheshire Plain, Triassic deposits of, 12.
Chessboard drainage, 13, 22, 26.
Chester, 82, 134; export of ore from, 3.
China Rake, 40, 41, 43, 66.
Chlorine, action of, 19.
Chwarel-lâs Veins, 66.

Classifiers, 133.
Clawdd-ffordd Joint, 57.
Clay in swallow-holes, 93.
Clay, yellow, in cross-courses, 9.
Clay-filled fissures, 34.
———— lochs, 137.
———— lodes, 60, 66, 68, 87, 88, 136.
Clwt-militia, 53, 60, 61; Mine, 60; Vein, 21.
———— (Beili-gwyn) Vein, 59, 60.
Clwyd, Vale of, 4, 5, 11, 12, 30, 31, 36; geology of, 30, 31.
Clwydian Hills, 4, 7, 36, 37.
Clywedog, River, 105, 107, 108, 110.
Coal, in Cefn-y-fedw Sandstone, 91, 92; in Holywell Shales, 45, 57; in Limestone Series, 37.
Coal, Top Sulphur, 29.
Coalfield, Flint and Denbigh, revision of, 4.
Coal-gas, 22, 119, 126.
Coal Measures, 104, 105; Lower, 5, 7, 17, 30, 31, 36, 38, 39; ore in, 38, 80. *See also* details of Mines. Middle, 5, 7, 17.
Coal-seams, 117.
Cobden and Bright, Messrs., 138.
Coed Cae Dentir, 50.
Coed Cae Plwm, 51.
Coed Cae porfa, 50.
Coed-carreg-Dafydd Mine, 35.
Coed-Cynric Lode or Vein, 17, 93.
Coed-du, 78; cross-course, 78, 79, 84; Vein, 78, 79.
Coed-Hendre Vein, 77, 139; section of, 140.
Coed-mawr, 115.
Coed-Pen-y-gelli, 49.
Coed Poeth Mine, 116.
Coed-saith-aelwyd, 49.
Coed-y-cra, 23, 70.
Coed-y-fedw Lode, 17.
Coed-y-fron, 59.
Coetia-ball (Picton or Gyrn-fawr) cross-course, 22, 52, 53, 59.
Coetia-Butler, 53, 60.
Coetia-dwr Vein, 49.
Coetia-eithin, 55.
Coetia-llys Joint, 39.
Coetia-mawr, 58, 59.
Coetia'r-odyn cross-course, 52.
Coetia'r-ysgall Vein, 78, 79.
'Coke,' 8, 41.
Coke Hole, The, 41.
Coleshill, 2.
Colomendy, 93.
Colwyn, 4.
Concealed lead-field, possible, 17.
Concentration-plant, Halkyn Mines, 133.
Conglomerates, 30, 36.
Connah's Quay, smelting-works at, 3.
'Conqueror of Wales' Shaft, 25, 83.
Copper-ores, 13, 14, 54, 78, 116, 130; phosphorescent, 91.
Copper pyrites, 8, 9, 11, 17, 49, 70; needles of, 64, 66, 67, 77.
Corals, in limestones, 37.
Cornel-llwyd String, 63.
Cornel-pylle Joint or Vein, 57, 58, 124.
Cornel-y-cae cross-course, 128, 132; loch, 132.
Cornstones, 30.
Coronation Lode, 120.
County Gaol, Old, 91.
Craig, 86.
Craig-boeth Vein, 108.
Craig-y-bryniau Vein, 98.
Craig-y-cythraul, 114, 115.
Craig-y-forwyn, 114, 115.
Craig-yr-adar, 115.
Crecas, 53, 54, 61.
Creigiawg Lode, 101.
Creigiog-isaf, 101.
Crockford's Lode, 67, 68; section across, 74.
———— Shaft, 23.
Croes-ati, 1.
Croft, James, 75.
Cross-courses, 8–9, 12; absence of blende and calamine in, 14; copper-ore in, 17; numerous near Holywell, 52–53; influence on drainage, 22, 23; crossing Milwr Vein, 58–61.
Cross-courses and Veins, 8–9; deposition of ore in, 12.
Cross Leavings Vein, 64.
Crown, claim to mines and minerals, 2.
Crown Inn, 85.
Crych Vein, 108.
Cwt-coed, 77.
Cycoed day-level, 77.

Davey's Shaft, Bryn-celyn Lode, 25.
Davies, Capt., 60.
Davies, D. C., 21.
Davies, the Rev. Walter, 116.
Davies's Vein, 57.
Dean's Mine, 112.
Deborah Lode, 89.
———— Mine, 92.
Dee Bank, 28, 118.
Dee, estuary of, 26.
Dee Valley, 7, 103.
———— Syncline, 103.
Deep drainage, 15–17; influence on future of lead-mining, 23.

Deep Level Lode, 23, 68–71; section across, 74.
———— Mine, 14, 69, 146.
———— Tunnel, 23, 70–72, 131, 132. *See also* Halkyn Tunnel.
Denbigh Consolidated Vein, 21.
Derwen, 63.
Derwen-bâch, 57.
Derwen-fawr, 57, 63.
Dewey, H., 12.
Dillwyn & Co., Messrs., 134, 143.
Dingle Mine, 14.
——— Vein, 68.
Dixon's Lode, 135.
Dogpit Vein, 66.
Dollies, 133.
Dolomitic limestone, 114.
Dolphin Lode, 120.
Drabble, G. C., 13.
Drainage, 13, 14, 16, 22–29. *See also* details of Mines. Chessboard and staircase, 13, 22, 26; influenced by rock-structures, 22, 23; Schemes, 23–29.
Drainage-areas, map of, 24, 71.
Dressing of ore, 22, 72, 88, 128.
Dressing-floors, 144.
Drill Lode, 120.
Drilling for ore, 22.
Druid Inn, 51, 55.
Dulas, River, 31; Valley, 32.
Dyserth, 1, 7, 11, 36, 38; Castle, 40; Mine, 42.

Earth-movements, 12, 13.
East Garreg-boeth Lode, 143.
East Halkyn Grant, 137.
———— Mine, 16, 25, 132–138.
———— Mining Co., 72, 131, 134.
East Iron Shaft, 80, 81.
East Long Rake Mine, 67.
East Maes-y-safn Mine, 28, 93, 94.
———— shaft-section, 93.
———— Vein, 21.
East Pant-du Flat, 17.
East Pant-y-gôf Lode, 10, 11, 20, 125.
———— Mine, 10.
Ede, J. A., 99.
Eden, Vale of, 4.
Edward I, 2.
Efail-Parcy, 77.
Eglwyseg escarpment, 103.
—— —— Mine, 114, 115.
———— Mine Extension, 115.
———— Rocks, 11.
———— Vein, 114.
Eisteddfod, 107.
Electrical Metallurgical Co., Ltd., 134.
Electro-chemical processes, 19, 134.
Elizabeth, Queen, 2.
Ellis, Capt., 77.
Ellis's Vein, 57, 124.
Enrichment of ores, secondary, 14.
Erryrys, 28, 98.
Erw Vein, 121, 122.
Erw-felin Shaft, section of, 79.
———— Vein, 79.
Explosives Department, 134.
Exportation of ore, 3, 20, 69.

Faults, as barriers to mineral solutions, 13; as carriers of water, 28; displacement of one set by a second, 8; related to strike and dip of beds, 8; systems of, 4, 7–9, 104; throw of, 8.
Fawnog Mine, 89, 146.
'Feeders' of veins, 60.
Ffernant Dingle, 30.
Ffrith, 53, 59–61.
Ffôs-y-bleiddiaid Mine, 1, 31, 32.
Ffyddion, 49.
Ffynnon-Fair Vein, 43.
Finlayson, A. M., 10, 12–14.
Fireclay-pits, 66, 93.
'First Shale,' 141, 143.
'Flat-limestones,' 89–94, 96–99.
'Flat-measures,' 9, 37, 90–94, 96–99; sand in, 94.
Flats of ore, 11, 13, 37, 40, 62, 64–66, 75–77, 92, 94, 113, 116, 125, 130, 136, 138, 139; in cherts, 10; scarcity of blende in, 40; secondary deposition of ores in, 14.
Flingallt cross-course, 53.
Flint, 1, 2, 4, 8; smelting-works at, 3.
'Flitches' of ore, 127.
Fluorine, 18.
Fluorspar, 8, 9, 11, 18, 67, 75, 93, 101, 109, 132–134, 137.
Foel-dda, 61.
Foel-ddu fireclay-pit, 66.
Fossil Vein, 108.
Four Crosses, 107.
Francis, Capt. J., 15, 28, 35, 60, 121.
———, Capt. M., 15, 100.
Fron, 67, 68, 103.
Fron-Cysyllte, 103.
Fron-Fawnog Mine, 89; Vein, 89.
Fron-haul, 87, 93, 94; Mine, 92.
———— Little Flat, 90–93.
Fron-heulog Vein, 21.
Fron-isaf, 91, 93; Vein, 76, 91, 92.
Fron-uchaf, 92.

Galena, argentiferous, 8, 13, 15, 49; beds of, 9; concentration of, 9; distribution of, 8–13; earthy, 9; in bunches, 44, 118, 121, 136; in 'flitches,' 127; in lumps, 69, 77, 87-89, 128, 145; laminated, 8; needles of, 77; re-arrangement of, 9; silver in, *see* Silver in ore; supposed secondary, 12.
Galop cross-course, 58.
Galopell (Caleb Bell) cross-course, 58.
Garreg, 47; Fault, 47, 48; Mine, 48; Mountain, 48; Vein, 48.
Garreg-boeth Lode, 16, 20, 21, 25; section of, 143.
——— (East), 143–145.
——— Mine, 146.
Garreg-llwyd (Hugh Pierce) Vein, 64.
Garreg-y-cochion Vein, 97.
Garth Level, 81.
Gas in mines, 22; in workings, 119, 126.
Gelli-Fowler, 61.
Geology, Prestatyn to the Bala Fault, 36–38; the Bala Fault to Llanymynech, 103; Vale of Clwyd, 30, 31.
Gin Vein, 67.
—— Mine, 61.
Gladstone Vein, 20, 21.
Glacial Drift, 31, 33, 36, 38, 40, 42, 46, 119; gravel, 32, 33, 43, 77, 90; sand and gravel, 97, 119, 123; ore in, 85.
Glan-Alyn, 90.
Glan-yr-afon, 78.
Glascoed, 33.
Glol Mine, 48.
Glyndwr Mine, 93, 146.
——— Shaft, East Maes-y-safn Mine, 28.
Golch Hill Lode, 61.
——— (West Holloway) Lode, 53, 54.
Golden Grove, 42.
——— Mine, 41.
Gomerian Level, 113, 114.
Goodchild, W. H., 12.
Goodwin Lode or Vein, 17, 97.
Gors Mine, 61.
Gorsedd, 37.
Gorsedd Black Limestone quarry, 118.
——— day-level, 51, 117, 118.
——— (Merllyn) Lode or Vein, 21, 55, 56.
Gorsedd and Sinclair United Mine, 56.
Gossan, 44.
Government (War) Drainage Scheme, 23, 25.
Graig-fawr, 38, 40, 41.
Graig-poeth Mine, 112.
Graig-wolf, 28.
Grainger's Vein, 64, 122.
Grain-ore, 20, 69.
Grand Turk Level, 108.
Grange, The, 53.
——— Mine, 55.
Gravel, Glacial, 32, 33, 43, 77, 90.
Gravel-ore, 10, 40, 43, 48, 85.
Great Halkyn Fault, 37.
——— Lode, 11, 18, 20, 128, 131–135, 137, 138; section across, 74.
Great Holway Mining Co., 51.
——— Laxey Mine, I.O.M., 19.
——— Melbourne Mine, 112.
Green ore, 62.
Greenfield, 17, 52.
Greenford, 133.
Griffiths & Co., Messrs., 19.
Gronant, 42, 43; Mill, 43; Mine, 43.
Grosvenor, Earl, 82.
——— (Westminster) Lode, 135.
——— Mine, 66.
———, Sir Richard, 2.
——— Vein, 73.
Gwaenysgor, 41, 42.
Gwallter Mechain, 116.
Gwern-y-mynydd, 37, 80; Flat, 17, 28; Little Flat, 91; Mine, 90–92, 146; Vein, 21, 95.
Gwersyllt Hall, 29.
Gwespyr Sandstone, 5, 45, 47.
Gwrych, 31; Castle, 32.
Gwter-Siani, 114; Vein, 114.
Gwynne, Richard, 2.
Gyrn-fawr cross-course, 52, 53.

Hafod, 48, 89, 90.
Hafod-dafolog, 102.
Hafod-wen, 108; Mine, 146.
Halfway House, 51, 52, 59.
Halkyn, 3, 11, 22, 24, 49, 68, 127, 134, 143, 146; Castle, 70; Church, 126–128; Hall, 64, 65; Terrace, 66.
——— District Mines Drainage Co., 23, 24, 26, 81, 124, 142, 144.
——— Drainage-area, 24, 26, 71.
——— Mines, 15, 16, 22, 25, 128–134, 142; concentration-plant, 133, 138.
——— Mining Co., 18, 20, 128, 137.
——— Mountain, 3, 17, 37, 38, 49, 59, 63, 65; section across, 74; veins on, 61–73.

Halkyn Tunnel (Deep Level), 14, 16, 23–25, 28, 68, 70, 79, 81, 83, 84, 129, 132–134, 138, 142, 143; branches of, 67, 72, 73, 133–136, 138, 141, 142, 144, 145; in section, 74.
Hand-dressed ore, 128, 145.
'Hard shaft' Vein, 57.
Harris, H. P., 29.
'Harrogate water,' 53.
Hawarden, smelting-works at, 3.
Hazel Grove Mine, 61.
Hên Rake, 68.
Henblâs Farm, 63.
Hendre, 38, 73, 138; Lode, 139, 140, 141; Mine, 12, 14, 25, 73, 146.
——— Valley, 38, 76, 77, 139, 142.
Hendre-figillt, 76, 77.
Hendre-foelas, 28.
Henry VII, 2
Hersedd, 73, 76.
Herward Mine, 26, 63, 125.
——— Shaft, section of, 120.
——— Vein, 57, 58, 124.
Hesp-Alyn, 78, 81.
Heward [? Herward] Mine, 146.
Higginbottom & Co., Messrs., 134.
Holland String or Vein, 47.
Holloway, 37, 49, 52; House, 51, 52.
——— (Holway) Mine, 27, 49.
——— Vein, 21, 51.
Holyoak String or Vein, 47.
Holywell, 1, 3, 11, 14, 17, 26–28, 41, 49, 50, 52, 55, 56, 59, 117, 118, 122, 124, 126, 127, 146; water-supply of, 27.
——— Level, 3, 49, 50.
——— Mine, 146.
——— Shales, 5, 7, 11, 36, 45, 53, 57, 63, 105, 119, 124–127; coal in, 45, 47.
——— Workhouse, 57.
Holywell-Halkyn Drainage-Area, 24, 26, 121.
——— Mining and Tunnel Co., 26, 118, 124, 126.
——— Tunnel. *See* Milwr Tunnel.
Home Office Plans, 33, 40, 47, 94, 108, 112, 139, 146, 147.
——— Statistics, 14.
Hope Mountain, 5, 7, 11, 37.
Hopewell, 53; Lode, 54, 61.
'Horse-clay,' 99.
'Horses,' 141.
Hotchkiss, Capt., 51, 52.
——— Mine, 52.
Hugh Pierce (Garreg-llwyd) Vein 64.
Hughes, G., 16.
Hunt, R., 2, 9, 32.
Hush Vein, 107, 108
Hwylfa-fer, 57, 64.

Iceland spar, 58, 59.
Ingleby, Mr., 82.
Iron-bearing waters, 45, 53.
Iron pyrites, 17; stalactitic, 42.
Iron Shaft, East, 80, 81; West, 26, 80, 81, 144.
Ironstone nodules, 61, 76.

Jamaica Flat, 17.
——— Mine, 9, 94, 146.
——— Vein, 21,
James, I, 2.
Jigs, 133.
Joints, influence on drainage, 22.
Joint-y-clawdd, 42–44.
Joint-y-pydew, 78, 145.
Jones, J. P., 119, 120.

Keldreston, 2.
Kelsterton Lode, 45.
Kelston Farm, 43, 45.
——— Lode, 45.
Knight, A. H., 18.

Langworthy String or Vein, 47.
Launders, 25, 83.
Laurium, Attica, lead-mines of, 13.
Lead, pigs of, 2, 83; rakes of, 2; recovery of, 19; scoria, 1; carbonate, 93, 94; sulphate, 62.
Lead-field, possible concealed, 17.
'Lead-Mine,' old, Maes-Maelor, 101.
Lead-ore. *See* Ore.
Lead-smelting works, 3, 45, 82, 83, 118, 134.
Lead-wash, old, 114.
Ledebroke, 2.
Limestone, 'Aberdo,' 5, 36, 45–48, 99, 101, 113. Argillaceous, 119; bituminous, 37; black, 5, 36, 37, and details of Mines; cherty, 31, 37, 41; coralline, 37; dolomitic, 114; nodular, 37; porcellanous, 37; sandy, 5, 36, 37, 103; silicified, 54.
Limestone flats, 89–94, 96–99. *See also* Flat-measures.
Limeworks, Minera, 107, 108, 112.
Lisburne Mine, 147.
'Little Duke' spring, 53.

Little Flat, Fron-haul, 91–93.
———, Gwern-y-mynydd Mine, 91.
Liverpool, re-export of ore from, 3.
Llanarmon, 11, 26, 28, 37; Mill, 101; Mine, 99.
———— District, 3.
———————— Lodes, 100.
———————— Mines Drainage Co., 28, 94.
Llanarmon District Mines Drainage Scheme, 16.
Llanarmon District Mines Drainage Tunnels, 23, 28.
Llanasa, 37, 41, 45, 46.
Llandegla, 7, 11, 36, 37, 102.
Llandulas, 31, 32.
Llanelidan Fault, 7, 8, 13, 23, 101, 102.
Llanelidan-Bala Fault, 13.
Llanerch-y-môr, smelting-works at, 3.
Llanfair Mine, 147.
Llanferres, 95, 97; Fault, 97.
Llangollen, 6, 7, 11, 103.
Llanymynech, 3, 5, 7, 103; Hill, 1, 7, 103, 116.
Llawnt, 103.
Llewellyn Mine, 112; Vein, 107.
Lloc, 55; Mine, 146.
—— Mining Co., 55
—— (Rhydwen) Mine, 56.
Llongle Mine, 63, 126.
Lloyd, John, 79.
Llwyn-traus cross-course, 79, 84.
Llwyn-y-cosyn Mine, 62; Vein, 62.
Llyn-Cyfynwy, 101.
'Llynypandu' Mine, 81, 82. *See also* Llyn-y-pandy Mine.
Llyn-y-pandy Lode or Vein, 3, 25, 81–84, 142.
———————— Mine, 11, 16, 20, 25, 146; section of, 83.
———————— Mining Co., 81.
Llysfaen, 30.
Lochs, 122, 123, 132; clay-filled, 137; sand-filled, 27, 122, 123.
Lodes, clay-filled, 60, 66, 68, 87, 88, 136; sand-filled, 122, 123, 136.
London, re-export of ore from, 3.
———— House, 93.
Long Rake, 67.
Lord Hill Joint, 53, 54, 61.
Louis, H., 108.
Lower Brown Limestone, 5, 7, 36, 37, 103.
——— Coal Measures, 5, 7, 17, 30, 31, 36, 38, 39, 80.
——— Grey Limestone, 5, 7, 30, 31, 36, 37, 103. *See also* details of Mines.
——— Palaeozoic Rocks, 103, 105, 107.
Lower Park Mine, 112, 113.
Ludlow rocks, 30, 31.
Lump-ore, 20, 69, 77, 83, 87–89, 128, 145.

Maen-bras Lode, 66.
Maes-Maelor Farm, 101.
———— sett, 107.
Maes-y-droell, 99.
Maes-y-faen Mine, 147.
Maes-y-pwll Lode, 11, 101,
Maes-y-safn, 92, 101; Lode or Vein, 17, 21, 95–98; Mine, 14, 94–96.
Maes-Whitford cross-course, 52.
Magmatic solutions, 12, 13.
Main (Old) Vein, Minera, 105–110.
Malachite, 8, 11, 130.
Manganese, 11, 77, 137.
Marcasite, 58.
Marian, 36; Lode (Talacre), 43, 44; String, 105.
Marian-bâch, 36.
Mather's (Sankey's) Vein, 64.
Mavor, Mr., 19.
Mechain, Gwallter, 116.
Metasomatic replacement of limestone, 12, 123.
Merllyn Farm, 56.
———— Lode or Vein, 21, 49, 55, 56, 117.
———— and Gorsedd Mine, 51.
———————— Vein, 21, 55, 56.
———— and Waen Mine, 56, 117, 118.
Middle Coal Measures, 5, 7, 17.
Middle Joint, Powell's Lode, 135, 136.
Miller's Vein, 52.
'Millstone Grit' (Cefn-y-fedw Sandstone), 36, 38; Pennine type, 5, 7, 103.
Milwr, 24, 56, 124; Farm, 57; Fault, 37.
——— Mine, 28, 57, 58, 119, 124–126.
——— Shaft-section, 120.
——— Tunnel (Holywell-Halkyn Sea-Level), 16, 17, 23, 26–29, 63, 83, 118–125, 127, 138, 142; cost of driving, 124; flow of water, 123; section along course, 119; speed of driving, 124.
——— Tunnel and Lodes cut, 118–124.
——— Vein, 54, 56–61, 63, 124, 125.
———————— and adjoining veins, 56–61.
Mine tailings, 19, 41, 47, 112, 134, 143.

Minera, 5, 7, 8, 11, 13, 102–105, 147.
——— Boundary Mine, 108.
——— District, suggested drainage-scheme, 29.
——— Fault-belt, 102, 104.
——— Limeworks, 107, 108, 112.
——— Mill, 110.
——— Mines, 1, 3, 10, 11, 15, 17, 83, 102–112, 147; Company reports, 109; day-levels, 110; deep day-level, 109, 110; drainage, 108–110; map of district, 104; sections, 106; output, 111, 112.
——— Mining Co., 110.
——————— District, map of, 104.
——— Mountain, 104, 105.
——————— Mine, 112.
——— Quarry Mine, 112.
——— Union Mine, 105.
——————— sett, 107.
Miners, Thomas, 94.
Mines, ancient tools in, 2; unwatered by tunnelling, 27.
Mining, deep, for ore, 17.
——— methods, 21, 22.
Minsterley, 14.
Moel-Findeg, 87, 95, 96.
Moel-garegog, 102.
Moel-y-Crio, 69; Mine, 12, 70.
Moel-y-gaer, 37, 72, 131, 135, 136; Fault, section across, 74.
Moelydd, 116.
Moissenet, M. L., 43.
Mold, 4, 8, 68, 82, 89, 93, 138, 146; Mines, 73.
——— and Denbigh Railway, 139, 143.
Morton, G. H., 3.
Mostyn, 146.
———, Sir Pyers, 50.
Mount Halkyn Mine, 16, 20, 25, 89.
——— Pleasant Flat, 17.
——————— Run, 94.
Mountain Shaft, 20.
Mwdwl-eithin, 53.
Mwyn-bwll, 78, 79; Mine, 78; Vein, 21, 78.
Mynydd-du, 99.

Naid-y-march, 53, 54.
Nant-Adda adit, 100.
Nant-Alyn, 78, 80; cross-course, 78, 80, 84–90, 143, 144.
Nant-figillt, 73, 139; section across, 74.
———— Fault, 8, 28, 73, 128, 131, 142; section across, 74.
Nant-hil-brwc, 57.
Nant Lode, 100.
Nant Mill, Coed-y-cra, 23.
————, New, 110.
————, Minera, 105.
————, Prestatyn Castle, 41.
———— Wood, 105.
Nant Mine, 99, 100.
Nant-Minera Mines, 105.
—— Vein, 16, 17.
Nant-y-cwm-mawr, 114; Vein, 114.
Nant-y-ffrith, 115.
Nant-y-Flint, 65.
Nant-y-fuwch, 63, 64.
Nant-y-mwyn Mine, 41.
Needles of copper pyrites, 64, 66, 67, 77; of galena, 77.
Nerquis, 28, 68; Mountain, 97.
New Caeau Mine, 64, 121, 126.
—— Chwarel-lâs Vein, 66.
—— Flat, 65.
—— Garreg-boeth Vein, 77, 78, 143.
—— Minera Mine, 109, 112, 147.
—— Nant Mills, 110.
—— North Halkyn Mine, 16, 25, 28, 67.
—— Pant-y-gôf Shaft, section of, 130.
—— Pant-y-nef cross-course, 53.
———————— Mine, 55; Vein, 60, 61.
New Red Sandstone, 4.
Nodular limestone, 37.
Nodules, of galena, 116; of ironstone, 61, 76.
North Branch (Great Halkyn Lode), 137; (Powell's Lode), 135, 136.
——— Cross, Milwr Mine, 119, 125, 126.
——— Henblâs, 119; Mine, 63.
——— Hendre day-level, 79; Flat, plan of, 75; Mine, 11, 15, 16, 23, 25, 26, 28, 76, 138–142; Mining Co., 25, 138; Vein, 21.
———'Joint (Powell's Lode), 135, 136.
——— (Langworthy) String or Vein, 47.
——— Lode, Minera, 105, 109; Pant-y-mwyn, 85.
——— Pant-y-nef Mine, 55.
——— Prince Patrick Mine, 62, 64.
Northop, 1, 2.

Ogof, The, 116.
Oil, exudation of, 129.
Oil-flotation process, 134.
Old Caeau Mine, 121, 126.
—— Chwarel-lâs Vein, 66.
—— Flat, The, Prince Patrick Mine, 65.

Old Garreg-boeth Lode or Vein, 78, 79, 81, 143, 144.
—— Hall, 68.
—— Henblâs Vein, 64.
—— Hendre Vein, 21.
—— Herward Vein, 58.
—— Holloway Vein, 49–58, 61.
—— Hwylfa Lode or Vein, 58, 119, 124, 125.
—— Milwr Mine, 58, 126; Vein, 57, 119.
—— North Hendre Mine, 76, 77, 138.
—— Pant-y-gôf Vein, 129.
—— Pant-y-nef cross-course, 27, 52–54, 60–62; Mine, 55.
—— Rake, 68.
—— Whimsey Vein, 52.
Order of deposition of ores, 13, 14.
Ordovician rocks, 4, 7, 11–14, 114.
Ore, copper, 8, 9, 11, 12, 17, 49, 54, 64, 66, 67, 70, 77, 78, 91, 116, 130; manganese, 11, 77, 137.
Ore (Lead and Zinc), general account, 7–14; analyses and assays, 18–21; deep mining for, 17; deposition of, 12–14; distribution of, 10, 11; dressing of, 22, 72, 88, 128; exportation of, 3, 20; minerals associated with, 8; origin and date of formation, 11–13; output of, 14–17, 111, and Pls. I and II; production of, 14–16; prospecting for, 22; regional distribution of, 11; required for war, 25; silver in, *see* Silver.
Ore, occurrence of; in 'bellies,' 48; in bunches, 44, 118, 121, 136; in caverns, 76; in clay, 62, 77, 128; in flats, 11, 13, 37, 40, 62, 64–66, 75–77, 92, 94, 113, 116, 125, 130, 136, 138, 139; in 'flitches,' 127; in Lower Coal Measures, 38, 80; in lumps, 20, 69, 77, 83, 87–89, 128, 145; in nodules, 116; in pipes, 9, 65, 66, 76, 77, 89; in pockets, 40, 76; in 'runs,' 9, 12, 13, 70, 89–91, 94, 96, 98–100, 139; in 'shoots,' 9, 77, 130, 136, 139, 141, 144; in 'tumblers,' 116.
Ore, varieties of, 8; blue, 82; brittle, 10, 137; clinker-like, 127; earthy, 9; grain, 20, 69; gravel, 10, 40, 43, 48, 85; green, 11, 62; potter's, 92; steel, 10, 109, 127, 137; white, 8, 20, 43, 82, 116; yellow, 116.
Ore-crushers, 133.
Oswestry, 7, 116.
Output of ore, 14–17; diagrams of, Pls. I and II, and p. 111. *See also* details of Mines.
Overlap, of limestones, 103; of Lower Coal Measures, 38.
Owen Glyndwr Inn, 94.

Pant, 49, 50, 54.
Pant Lode or Vein, 3, 13, 27, 64, 65, 99, 122, 123.
Pant-du, 97; Lode or Vein, 16, 17, 21, 28, 97, 146.
Pant-glâs, 87, 89.
Pant-Ithel Vein, 57.
Pant-terfyn, 98.
Pant-Wacco, 37, 49, 55–57; Fault, 49, 55, 56, 61.
Pant-y-buarth, 92; Mine, 16, 85–89, 146; Mining Co., 87, 88; Vein, 21, 86–88.
Pant-y-gôf, 68; Lode or Vein, 20, 21, 68–70; Mine, 69, 72, 146.
Pant-y-ffrith, 69; cross-course, 67–70, 123; Mine, 146.
Pant-y-garreg Mine, 48.
Pant-y-gwlanod Vein, 16, 17, 21, 99, 100.
Pant-yr-hwch, 48; Vein, 48.
Pant-y-mwyn Mine, 10, 16, 20, 85, 86; section of, 85.
———— Vein, 21, 84.
Pant-y-pydew, 64; Lode or Vein, 28, 62, 63, 121, 126; Mine, 63.
Pant-y-pwll-dwr, 3, 65.
Pantasa, 50, 57; Fault, 49, 54, 61; Monastery, 61.
Panton's Vein, 39, 40.
Parc-Arthur, 90, 91.
Park Farm, 87, 88.
—— Mine, 112, 113.
—— Vein, 112.
Parry's Flat, 65.
——— Mine, 64.
——— Vein, 21, 64, 122.
Partridge Vein, 51, 52, 54.
Penffordd-bedw, 55.
Pen-lan, 102.
Pen-y-ball, 52, 53, 56, 61.
Pen-y-bryn, 37, 57, 58, 67, 68; Mine, 58, 146; Shaft, 25, 26, 67.
Pen-y-corddyn-bâch, 31.
Pen-y-ffordd, 53, 61.
Pen-y-ffrith Vein, 46, 47.
Pen-y-foel sand-pit, 99.
Pen-y-fron Mine, 82, 146.
Pen-y-garreg Farm, 63.
Pen-y-garth, 85.
Pen-y-gelli, 76.
Pen-y-lan, 87.
Pen-y-pylle, 58.
Pen-y-sarn, 85, 86.
Pen-yr-Henblâs, 64; Vein, 21.
Pen-yr-hwylfa, 62, 63; Lode or Vein, 63, 119.
Pen-yr-orsedd Lode or Vein, 73; Mine, 73.

Peniel Chapel, 107.
Pennant, Thos., 1–3, 49, 53, 57, 58, 62, 65, 116.
Pentre chert-quarry, 42.
Pentre-bâch, 36, 93.
Pentre-cwm, 36.
Pentre Ffwrndan, 1.
Pentre-ffynnon, 48.
Pentre-Halkyn, 3, 64, 120, 126.
Pentre-hobin Lode or Vein, 17, 97.
Personoliaeth Vein, 48.
Perth-y-maen, 46.
Petters, Sir John, 2.
Phillips, J. A., 108.
Phillips's Lode, 66.
Picton cross-course, 52.
——— Mine, 59, 60.
Pilkington's Vein, 90.
Pipes of ore, 9, 65, 66, 76, 77, 89.
Pipes, secondary deposition of ore in, 14.
Plans, Home Office, 33, 40, 47, 94, 108, 112, 139, 146, 147.
Plantation Mine, 146.
Plâs captain, 61, 63.
Plâs-du, 101.
Plâs-Eglwysegle, 115.
Plâs-isaf, 65.
Plâs-newydd, 35.
Plâs-uchaf, 48.
Plâs-Wilkin, 78.
Plâs-Winter, 73; Mine, 20, 68, 127, 128.
Plâs-yn-coed, 107.
Plâs-yr-esgob, 85.
Plasau Mine, 62.
Pockets of ore, 40, 76.
Pool Park Mine, 113.
———— Vein, 113.
Porcellanous limestones, 37.
Portaway Lode, 53.
——— Mine, 50.
Porth-y-waen, 103, 116.
Pot-holes, 98.
Potteries, The, 40, 133.
'Potter's ore,' 92.
Powell's Lode, 10, 16, 134, 135–138; section of, 135.
——— Mine, 25.
Pre-Carboniferous rocks, 12.
Prestatyn, 5, 7, 11, 36, 37, 42, 146; Castle, 41; Fault, 42.
Prince Patrick Mine, 64, 65; output, 66.
Production of ore, estimated, 16
Prospecting for ore, 22.
'Pudding-bed,' 99.
Pumping from mines, 25, 28.
Pumping-engines, Minera, 110.
Purex Ltd., 133.
Pwll-gwyn-llan Vein, 67.
Pwll-heli, 98.
Pwll-melyn, 63, 66; Cottage, 57.
Pwll-y-blawd, 90.
Pwll-y-gaseg, 64; cross-course, 64.
Pwll-y-wrâch, 98.
Pydew Lode, 145.
Pyrolusite, 8.

Quarry Vein, 118.
Quartz, 8; crystals, doubly terminated, 12, 13, 123.
Queen of the Mountain Mine, 65.
Queensferry, 25, 134.
Quirk, Barton and Burns, Messrs., 133.

Race-Course, the old, 61.
Ragman Mine, 107, 108.
——— sett, 107.
——— Vein, 107, 108, 112.
Rainbow Inn, 91.
Red Lion, Holywell, 59.
—— Vein, 105–107, 109.
Refracting spar, 58, 59.
Replacement of limestone, metasomatic, 12, 123,
Residues, 18, analysis, 19; treatment, 22, 134.
Rhes-y-cae, 63, 67.
Rhewl cross-course, 76.
Rhosesmor, 25, 28, 72, 73, 134, 135, 138; Anticline, 131. 134–136; Branch of Halkyn Tunnel, 135, 136, 138; Lode or Vein, 20, 21, 73, 135; Mine, 14, 15, 23, 72. 134.
———— Mining Co., 134.
Rhôsllanerchrugog, 105.
Rhuddlan, 2.
Rhyd-Alyn [Rhydalyn] Vein, 21, 84; adit, 84; Mine, 84.
Rhydfudr Mine, 126.
Rhyd-y-goleu, 67.
Rhydwen (Lloc) Mine, 56.
Rhydymwyn, 7, 38, 73, 79, 80, 83, 138, 142; Foundry, 80, 84, 144, 145; Mine, 146; Station, 138, 143.
Rhyl, 4, 146.
River Alyn, 29, 79–81, 85, 86, 90, 92, 95, 97, 98, 100.
—— Clywedog, 105, 107, 108, 110
—— Dulas, 31, 32.
—— Terrig, 28.
Roberts, Capt. J., 92, 96.
Rock and Minera Western Boundary sett, 108.
Rock Vein, 108.

Roman coins, 116.
——— Emperors, stamps of, 2.
——— fosse, 32.
——— remains, 1, 2, 32, 33.
——— workings, 1, 2, 32, 33, 38, 67, 78, 103, 116.
Roskell, Mr., 53.
Roskell's Day-level, 63, 64.
——— Shaft, Holway Mine, 27.
Rost-y-cegin (America) Vein, 58.
'Round ore,' 43.
Rowley's Rake, 3, 65.
Royal Oak Inn, 77.
Royalties on mines, 34, 113.
Runs of ore, 9, 12, 13, 70, 89–91, 94, 96, 98–100, 139.
Ruthin, 4, 8.
——— Road, 115.

St. Asaph, 11.
St. David's Mine, 61.
St. Helens, 133, 143; smelting-works, 3.
St. Winifred's Well, 23, 27, 28, 49, 50, 59, 60, 62, 63, 122.
Saith-aelwyd Cottage, 153, 154.
Sand, 37; as vein-stuff, 40, 41, 127; in caverns, 90; in 'flat-measures,' 94; in lochs or vughs, 27, 122, 123; in lodes, 122, 123, 136; in pipes of ore, 89; in swallow-holes, 93, 98; in veins, 60, 65.
Sand-pit, Pen-y-foel, 99.
Sand Vein, 107.
Sandy Limestone group or series, 5, 36, 37, 103. *See also* details of Mines.
Sankey's (Mather's) Vein, 64.
Saxons, mines worked by, 2.
Sea-level Tunnel. *See* Milwr Tunnel.
'Second Shale,' 138, 141.
Seven Stars Vein, 60.
Shales, determining deposition of ore, 13; local, in Carboniferous Limestone, 103.
'Shoots' of ore, 9, 77, 130, 136, 139, 141, 144.
Shropshire mines, 14.
Siambr-wen, 31; Fault, 32.
Silica, in spars, 9.
Silica-sand, 37.
Silicified limestone, 54.
Silicious vein-stuff, 40, 41, 43, 54, 60, 65, 76, 123.
Silurian fossils in Basement-Beds, 30.
——— rocks, 4, 7, 11, 13.
Silver, distribution of, 10; recovery of, 19, 134.
——— in ore, 8, 9, 14, 15, 18–21, 42–44, 47, 49, 60, 73, 76, 84, 86, 88, 89, 92, 109, 118, 127, 128, 130, 132, 137, 141.
Silver Rake, 11, 62–64.
Sinclair and Gorsedd United Mine, 56.
Sir Edward Lode, 52, 59.
——— Mine, 55.
Sir George's Field, 64, 65.
Slickensides, 39, 89, 108, 139.
Slimes, analyses of, 19; treatment of, 19.
Smelting-works: Bagillt, 3, 118; Buckley Mountain, 82; Connah's Quay, 3; Flint, 3; Hawarden, 3; Llanerch-y-môr, 3; Llyn-y-pandu, 83; St. Helens, 3; South Wales, 3, 134.
Smith's Bellows Lode, 60.
Smithy Gate, 59.
Society of Mines Royal, The, 2.
Solution, magmatic, 12, 13.
South Halkyn Co., 81.
——— ——— and Rhydymwyn Mining Co., 143.
——— Mine, 16, 20, 23, 25, 84, 143–145.
South Joint, Powell's Lode, 135, 137.
———, Talargoch Mine, 39.
South Level, Plâs-Winter, 128.
South Llyn-y-pandy Mine, 20, 23, 84; Vein, 84.
South Lode, Bryn-celyn, 80.
———, North Hendre, 139, 141.
———, Pant-y-mwyn, 85.
South Minera Mine, 113; sett, 113, 114; Vein, 113.
South Pant-y-gôf Shaft, 23.
South Pant-y-nef Mine, 55.
South Prince Patrick Vein, 21.
South Vein, Minera, 107.
——— ———, Pen-yr-Henblâs, 64.
South Wales, smelting-works in, 3, 134.
Spar, amber-coloured, 62; in lodes, 9; refracting, 58, 59.
—— Vein, 42, 47, 48.
Spatum Islandicum, 58.
Speedwell cross-course, 53.
——— Mine, 55.
Spelter, 19, 134.
Springfield, 65.
Springs, underground, 27, 28, 50, 53, 85, 110, 121–123, 135.
Staircase drainage, 13, 22, 26.
Stalactitic iron pyrites, 42.
Stalagmite, 32, 65.
Stamp Office Lode, 88.
Statistics, Home Office, 14.
'Steel-ore,' 10, 109, 127, 137.
Stockworks, 130.
Stockyn Hall, 54.
Strahan, Sir A., 43, 60, 65, 79, 94, 99.
Strike-faults, 22.
Sulphuretted hydrogen in waters, 53.

Sulphuric acid, 134.
Sutton, 2.
Swallow-holes, 62, 63, 65, 87, 93, 101, 108.
Swansea Vale Spelter Co., 134.
Symons, Brenton, map by, 107, 108, 112, 115,

Tailings, mine, 19, 41, 47, 112, 134, 143.
Talacre District Mining and Drainage Co., 44.
——— Hall, 44.
——— Mine, 10, 42–45, 146.
——— Vein, 41–43.
Talargoch Mine, 1, 10, 14, 38–41, 42, 44, 94, 95, 146; South Joint, 39, 40.
——— Vein, 40; section of, 39.
Talwrn, 105; waterworks, 115.
Tan-y-bwlch, 104,
Tan-y-goppa, 31.
Tan-y-graig Lode or Vein, 100, 101; Mine, 100.
Tan-yr-ogof, 32.
Tan-yr-onen Mine, 48.
Taylor and Sons, John, 83.
Taylor's Lode, Belgrave Mine, 17, 98; Prince Patrick Mine, 66.
——— Shaft, Hendre Mine, 23, 25, 28, 142.
Temperature of underground waters, 123.
Terfyn, 41.
Terfyn-dwydre, 48.
Terrig, River, 28.
Thorntree Vein, 62–64.
Tiddeman, R. H., 31.
Tilestones, 30.
Top-Eisteddfod, 107.
Top Flat, Bryn-gwyn quarries, 93.
———, Glyndwr Mine, 93, 94.
—— Sulphur Coal, 29.
Tre-Eden-Owen, 51, 55, 117.
Tree-trunks in veins, 68, 90, 91, and Pl. III.
Trelogan, 37, 46; Mines, 46, 47, 146; Vein, 46, 47.
Trevathen Lode, 88.
Trevor, 5, 103.
Triassic deposits, 12.
Trinity Church, Bwlch-y-ddaufryn, 86.
Trommels, 133.
True Blue cross-course, 52; Mine, 55, 112; Vein, 64.
Trymaen Vein, 49.
Trymaen-isaf Vein, 49.
Tufa, 87.
Tufaceous gangue, 34.
'Tuft,' 9, 64, 76.
'Tuftan.' 99.
'Tumblers' of galena, 116.
Tunnel, Cefnybedd, 29.
———, Halkyn. *See* Halkyn Tunnel.
———, Milwr (Sea-Level). *See* Milwr Tunnel.
Twelve Apostles Mine, 112.
——————— sett, 107.
Ty-mawr, 33.
Ty-newydd, 32.
Ty-uchaf, 115.
Tyddyn-Morgan Mines, 3, 31, 33.
Tyddyn-Shepherd Mine, 62.
Tyddyn-uchaf, 31, 45.
Tyddyn-y-barcud Vein, 77, 78, 139, 143.
Ty'n-twll, 49.

Union Vein, Halkyn Mountain, 66–68; Minera, 108.
Union and Boundary Mine, 112.
Unproved ground, 16.
Upper Grey Limestone, 5, 7, 30, 31, 36, 37, 103.

Vale of Clwyd, 4, 5, 11, 12, 30, 31, 36; Fault, 4, 13, 38.
Vale of Eden, 4.
Vale of Llangollen Fault, 13.
Valentine Mine, 59.
Valley, Afon-y-garth, 47; Dee, 7, 103; Dulas, 32.
Values of ores, Plates I and II, and Fig. 16.
Vanning-tables, 133.
Vein Crwn, 67.
—— Ganol, 101.
Vein-stuff, silicious, 40, 41, 43, 54, 60, 65, 76, 123.
Vein Susan, 79.
Vein-uchaf, 49.
Veins, 12; character of, Flintshire, 21; clay-filled, 60, 66, 68, 87, 88, 136; direction of, Flintshire, 21; feeders of, 60; influence on drainage, 22, 23; sand-filled, 122, 123, 136; tree-trunks in, 68, 90, 91, and Pl. III.
Veins and cross-courses, 8, 9; mineral contents of, 8, 9.
Verchoe, Capt., 65.
Vieille Montagne Co., 52.
Vivian & Co., Messrs., 134.
Volcnant Telegraph Station, 41.
Voryd, 33.
Vron, 29.

Vughs, 9, 122, 123; sand in, 27, 122, 123; secondary deposition of ore in, 14.

Wacco Mine, 61.
Wad, 8, 11.
Waen, 51, 56, 117.
Waen and Merllyn Mine, 51, 55, 56, 117, 118; section of, 56.
Waen-dyllog, 99.
Waen-lâs, 28; adit-level, 97; Mine, 97; Vein, 97, 98.
Waen-lâs-bâch Vein, 97.
Waen Mines, Ltd., 117.
Wagstaffe Lode or Vein, 62, 63, 67.
Walkers, Parker & Co., Messrs., 133, 143.
Wallside Mine, 146.
Wanlockhead Mine, 19.
War, effect on lead-market, 3, 82.
Warner, the Rev. Richard, 3, 82.
Warrant, 119.
Washing-floors, old, 100.
Waste-heaps worked, 47.
Water pumped, 81, 82, 138, 139, 142.
——, underground, temperatures of, 123.
Water-channels, underground, 9, 89.
Water-levels, 59, 60, 62, 63, 94, 113, 115, 119, 121, 127, 141, 142.
Water-tables, 22, 23, 27.
Water-tight barriers, 22, 23, 27, 28.
Water-wheels, 82, 83, 95.
Wedd, C. B., 13.
Weper, 2.
Wenlock Shale, 30, 31, 95; pebbles from, 87.
Wern, The, 105, 110.
Wern cross-course, 62, 128.
Wern-y-gaer, 23, 68, 72, 131, 135; anticline, 135; Mine, 68.
West Cefn-y-gîst sett, 114.
West Holloway Mining Co., 54.
———————— (Golch Hill) Lode, 53.
West Iron Shaft, 80, 81.
West Minera Mine, 112.
———————— sett, 107.
Westminster, Duke of, 99, 113.
———————— Lode (Nant and Bog Mine), 98–101.
———————— Lode (Rhosesmor), 73, 134, 135.
———————— Mine, 146.
West Trelogan Mine, 46.
White Horse Inn, 46, 47.
———————— Lode, 47.
'White lead,' 8, 43.
White Limestone, 5, 7, 36, 37, 103; Vale of Clwyd, 30, 31, 33. *See also* details of Mines.
White ore, 8, 20, 43, 82, 116.
White String or Vein, 47, 107.
Whitford [Whiteford], 1, 38, 48-50, 55, 117, 146.
Wilkinson, John, 82.
Williams, John, 32.
Windmill, The, 26, 121, 123, 124.
Wolves' Fosse, The, 32.
Woodlands Joint or Vein, 57, 124.
Wolfynton, 2.
World's End Vein, 114.
Wrexham, 147.
Wynne, G. F., 109.
Wynne, Sir George, 65.
Wynnstay sett, 114.
———————— Vein, 114.

Y-craig-bensyth, 115.
Yellow ore, 116.
Youde's Vein, 114.
Yr-odyn, 52.
Ysceifiog, 62.

Zinc-ore, *see* Ore.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

	s.	d.
VOL. I. TUNGSTEN AND MANGANESE ORES. By H. Dewey and C. E. N. Bromehead, B.A., with contributions by T. Eastwood, A.R.C.S., G. V. Wilson, B.Sc., and R. W. Pocock, B.Sc. 59 pp. 2 illustrations. Wrapper - (1915; Edit. 3, *in preparation*)		
VOL. II. BARYTES AND WITHERITE. By R. G. Carruthers, T. Eastwood, A.R.C.S., G. V. Wilson, B.Sc., R. W. Pocock, B.Sc., and D. A. Wray, B.Sc., with contributions by H. Dewey and C. E. N. Bromehead, B.A. 93 pp. 6 illustrations. (1915; Edit. 3, *in preparation*)		
VOL. III. GYPSUM AND ANHYDRITE. By R. L. Sherlock, D.Sc., and B. Smith, M.A.; AND CELESTINE AND STRONTIANITE. By R. L. Sherlock, D.Sc. 64 pp. 4 illustrations. Wrapper. (1915; Edit. 2, 1918)	2	0
VOL. IV. FLUORSPAR. By R. G. Carruthers, R. W. Pocock, B.Sc., and D. A. Wray, B.Sc., with contributions by H. Dewey, and C. E. N. Bromehead, B.A. 39 pp. 2 illustrations. Wrapper - - - - (1916; Edit. 2, 1917)	0	9
VOL. V. POTASH-FELSPAR, PHOSPHATE OF LIME, ALUM SHALES, PLUMBAGO OR GRAPHITE, MOLYBDENITE, CHROMITE, TALC AND STEATITE (SOAPSTONE, SOAP-ROCK AND POTSTONE), DIATOMITE. By A. Strahan, Sc.D., LL.D., F.R.S.; J. S. Flett, D.Sc., LL.D., F.R.S.; and C. H. Dinham, B.A., with contributions by C. T. Clough, M.A.; T. Eastwood, A.R.C.S.; and A. F. Hallimond, B.A. 43 pp. 3 illustrations. Wrapper. (1916; Edit. 2, 1917)	1	0
VOL. VI. REFRACTORY MATERIALS: GANISTER AND SILICA ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. RESOURCES AND GEOLOGY. 241 pp. 3 plates. 8 text figures. Wrapper - - - (1918; Edit. 2, 1920)	7	6
VOL. VII. MINERAL OIL, KIMMERIDGE OIL SHALE, LIGNITES, JETS, CANNEL COALS, NATURAL GAS. ENGLAND AND WALES. 125 pp. 1 plate. 7 text figures. Wrapper. (1918; Edit. 2, 1920)	5	0
VOL. VIII. IRON ORES: HÆMATITES OF WEST CUMBERLAND, LANCASHIRE AND THE LAKE DISTRICT. By B. Smith, M.A. 182 pp. 4 plates. 29 text figures. Wrapper - - (1919)	9	0
VOL. IX. IRON ORES (*contd.*). SUNDRY UNBEDDED ORES OF DURHAM, EAST CUMBERLAND, NORTH WALES, DERBYSHIRE, THE ISLE OF MAN, BRISTOL DISTRICT AND SOMERSET, DEVON AND CORNWALL. By T. C. Cantrill, B.Sc., R. L. Sherlock, D.Sc., and H. Dewey. 87 pp. 7 text figures. Wrapper - - - - - - (1919)	3	6
VOL. X. IRON ORES (*contd.*). THE HÆMATITES OF THE FOREST OF DEAN AND SOUTH WALES. By T. F. Sibly, D.Sc. 93 pp. 14 text figures. Wrapper - - - - (1919)	4	0
VOL. XI. THE IRON ORES OF SCOTLAND. By M. Macgregor, B.Sc.; G. W. Lee, D.Sc.; G. V. Wilson, B.Sc.; with contributions by T. Robertson, B.Sc., and J. S. Flett, F.R.S. 240 pp. 18 text figures - - - - - - (1920)	10	0
VOL. XII. IRON ORES (*contd.*). BEDDED ORES OF THE LIAS. OOLITES AND LATER FORMATIONS IN ENGLAND. By G. W. Lamplugh, F.R.S., C.B. Wedd., B.A., and J. Pringle. 240 pp. 8 plates. 12 text figures. Wrapper - - - (1920)	12	6
VOL. XIII. IRON ORES (*contd.*). PRE-CARBONIFEROUS AND CARBONIFEROUS BEDDED ORES OF ENGLAND AND WALES. By Sir A. Strahan, K.B.E., Sc.D., LL.D., F.R.S.; W. Gibson, D.Sc.; T. C. Cantrill, B.Sc.; R. L. Sherlock, D.Sc., and Henry Dewey. 123 pp. 3 plates. 10 text figures. Wrapper - (1920)	7	6

	s.	d.
VOL. XIV. REFRACTORY MATERIALS: FIRECLAYS. RESOURCES AND GEOLOGY. 243 pp. 4 plates. 13 text figures. Wrapper (1920)	8	0
VOL. XV. ARSENIC AND ANTIMONY ORES. By Henry Dewey, with contributions by J. S. Flett, O.B.E., LL.D., D.Sc., F.R.S., and G. V. Wilson, B.Sc. 59 pp. 1 plate. 2 text figures. Wrapper - - - - - - (1920)	3	0
VOL. XVI. REFRACTORY MATERIALS: GANISTER AND SILICA ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. PETROGRAPHY AND CHEMISTRY. By Herbert H. Thomas, M.A., Sc.D.; A. F. Hallimond, M.A., and Ernest G. Radley. 115 pp. 7 plates. 6 text figures. Wrapper - - (1920)	5	0
VOL. XVIII. ROCK-SALT AND BRINE. By R. L. Sherlock, D.Sc. 121 pp. 2 plates. 16 text figures. Wrapper - (1921)	5	0

In course of Publication.

VOL. XVII. THE LEAD, ZINC, COPPER AND NICKEL ORES OF SCOTLAND. By J. S. Flett, D.Sc., F.R.S., and G. V. Wilson, B.Sc.

VOL. XIX. LEAD AND ZINC ORES IN THE CARBONIFEROUS ROCKS OF NORTH WALES. By Bernard Smith, M.A.

VOL. XX. LEAD AND ZINC: THE MINING DISTRICT OF NORTH CARDIGANSHIRE AND WEST MONTGOMERYSHIRE. By Prof. O. T. Jones.

VOL. XXI. LEAD, SILVER-LEAD AND ZINC ORES OF CORNWALL, DEVON AND SOMERSET. By Henry Dewey.

VOL. XXII. THE LEAD AND ZINC ORES OF THE LAKE DISTRICT. By T. Eastwood, A.R.C.S.

VOL. XXIII. LEAD AND ZINC ORES IN THE PRE-CARBONIFEROUS ROCKS OF WEST SHROPSHIRE AND NORTH WALES. By Bernard Smith and Henry Dewey.

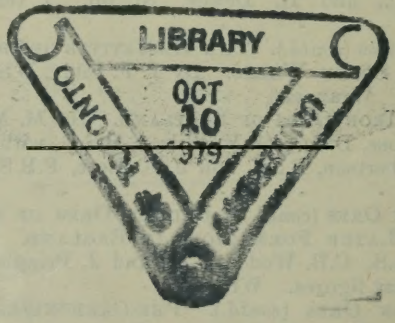
In Preparation.

VOL. ——. LEAD AND ZINC ORES OF NORTHUMBERLAND. By Stanley Smith, B.A., D Sc.

VOL. ——. LEAD AND ZINC ORES OF THE PENNINE DISTRICT. By R. G. Carruthers.

VOL. —— COPPER ORES OF THE WEST OF ENGLAND. By Henry Dewey.

VOL. ——. COPPER ORES OF THE MIDLANDS, THE LAKE DISTRICT AND NORTH WALES. By Henry Dewey.



Printed under the authority of HIS MAJESTY'S STATIONERY OFFICE
By Eyre and Spottiswoode, Ltd., East Harding Street, E.C.4,
Printers to the King's most Excellent Majesty.

SERIAL